Is the Financial Market a Mechanism for Environmental Overcompliance?

by

Julie Mallory

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Graduate Department of Economics
University of Toronto

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Abstract

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Climate change legislation is financially and politically costly. Financial markets have the capacity to encourage companies to do more than what is required by law (i.e. over-comply), and this could lead to socially optimal outcomes without the costs.

First, I examine how the responses of Canadian companies to a voluntary survey regarding carbon emission levels affect those companies’ valuations. I employ a signaling framework where companies choose between two signals - disclosure and nondisclosure - and where investors are uncertain about the likelihood of legislation in addition to company type. I test the prediction of the model that disclosure increases company value only when investors believe legislation is likely. I find that withholding emissions information resulted in average daily abnormal returns of 3 basis points, and that disclosure resulted in average daily abnormal returns of -11 basis points in the days surrounding the submission of survey responses. The level of emissions disclosed is found to be irrelevant.

Second, I examine the credibility of green legislative threat. The economic climate impacts the government’s ability to credibly threaten new environmental law, and so I model a company’s pollution decision as a function of the economic climate. In times of recession, companies may choose to pollute heavily since they believe that the likelihood of legislation is low. As a first step in evaluating the model empirically, I use differences-in-differences regressions to estimate the effect of legislative threat during recession on company value. Although the value of carbon-intensive companies decreased initially in
reaction to legislative threat, the relative value of these companies increased as the depth of the recession becomes more apparent. I find that on average the legislative threat of an emission trading scheme reduced Tobin’s Q by 18% in the initial stages of the recession, but as the recession deepened the legislative threat effect was eliminated.

My results suggest that financial markets combined with a credible threat of legislation could provide encouragement to companies to overcomply with current regulations, possibly to the extent that is socially optimal. More research on factors affecting company carbon emissions levels and intensity is required.
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Chapter 1

Introduction

1.1 Overview

Climate change legislation is financially and politically costly. Encouraging companies to overcomply with current regulations (i.e. do more than what is required by law) could lead to socially optimal outcomes without the costs. Financial markets have the capacity to provide such motivation. In this dissertation I examine the financial market reaction to actions relating to climate change risk with the purpose of better understanding how investors interpret this information and how these markets can be used to encourage environmental overcompliance. One example of overcompliance is to voluntarily disclose environmental information beyond legal requirements.

Climate change is a major policy issue in many countries. Uncertainty about future climate change regulation may cause varying beliefs about the likelihood of such regulation, and thus it is an open question how investors respond when companies signal to either reduce or ignore carbon emissions. In the U.S. and Canada, most companies are not obligated to disclose annual carbon emissions. Some companies have decided to overcomply with current regulations however, and voluntarily disclose this information.

\(^1\)Carbon emissions are the most common type of greenhouse gas emissions, such that the terms are often used interchangeably.
It is possible that investors may find to be informative (1) the level of emissions disclosed, and (2) the disclosure decision itself. I examine both these possibilities, and in particular I examine how the responses to a voluntary survey requesting that companies disclose annual carbon emission levels affects the market value of those companies. I find that withholding carbon emissions information resulted in average daily abnormal returns of 3 basis points, and that disclosure resulted in average daily abnormal returns of -11 basis points in the days surrounding the public release of the survey responses. The level of emissions disclosed is found to be irrelevant.

My results suggest that most investors considered future regulation in Canada to be distant, unlikely, or not costly. At the time, any threat of broad-based and significant climate change policy was not very credible. Previous research suggests that there was no credible threat in Canada during the years 1993-1999 (Antweiler (2003)). It is interesting to consider that my results may have been quite different if there had been a significant and credible regulatory threat in Canada at the time. If the threat of regulation is strong then there can be increases in social welfare to levels achieved under regulatory action but at a lower cost (Segerson and Wu (2006)).

Historically, Canadian and American regulatory agencies have monitored and regulated only toxic emissions such as methanol, but not carbon emissions. Since legislation has been the more likely source of climate change policy, I examine the potential for legislative threat to be an effective means of carbon emissions reduction. I find that on average the legislative threat of an emission trading scheme reduced Tobin’s Q by 18% in the initial stages of the recession, but as the recession deepened the legislative threat effect was eliminated.

There are two main types of environmental law. One is legislation - created by legislature (i.e. a deliberative assembly) and passed by federal or provincial/state governments.

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2Toxic emissions are pollutants that are known or suspected to cause serious health or environmental effects. In late 2009, the U.S. Environmental Protection Agency (EPA) was granted authority to regulate carbon emissions.
In the U.S., legislature is known as Congress, and in Canada it is known as Parliament. The other type of environmental law is regulation, which is a legal restriction from a government authority that describes how legislation will be implemented. Since regulation is connected to previous legislation, the two are not completely separate. For example, the Clean Air Act in the U.S. was a piece of legislation that included creation of the regulatory body known as the Environmental Protection Agency (EPA), an organization that has the authority to create certain environmental regulations. Other possible policy levers are legislative or regulatory threat. Although there is a fair amount of research on regulatory threat with respect to environmental law, to the best of my knowledge there is little to no research on legislative threat. I contribute to the literature by examining legislative threat, and in particular I test how a recession impacts its credibility.

The distinction between legislative and regulatory threat is an important one. Legislative threat is influenced more by political pressures, and there is evidence that governments delegate their legislative responsibilities to somewhat independent specialized institutions (i.e. regulatory bodies) in order to increase credibility (Gilardi (2002)). Periods of economic decline may affect the credibility of the government when threatening a type of legislation that negatively impacts companies. For example, in the U.S. it may be an unpopular political decision to enact new legislation such as an emissions trading scheme during a time of recession, however under current legislation such as the Clean Air Act, the EPA may initiate a similar type of environmental law. A model of the effect of legislative threat on a company’s choice of pollution level should incorporate the economic climate. I empirically examine how the strength of the legislative threat effect may vary over time with the economic climate. I find that even if legislative threat is initially credible, an unanticipated deterioration in economic conditions can eliminate credibility. Once in place, whether the law is regulation or legislation is probably irrelevant, and so the terms could be used interchangeably in many cases in this dissertation. I argue however, that the source of the threat is relevant as it relates to credibility.
Although Canada and the U.S. have yet to employ a significant national climate change policy such as an emissions trading scheme, certain regions and jurisdictions have initiated or plan to initiate such programs. Some jurisdictions also employ carbon taxes. In addition, there exist some voluntary programs with which companies may choose to participate, including the Carbon Disclosure Project and Climate Leaders. Within the last few years, both Canada and the U.S. have initiated programs that require certain companies to disclose the greenhouse gas emissions of their facilities. These programs are similar to other, much older programs in both countries that require companies to disclose toxic emissions.

Companies in the U.S. and Canada are required by law to disclose high levels of toxic emissions such as methanol. Investor reaction to these involuntarily disclosed emissions is typically negative (See Hamilton (1995); Konar and Cohen (1997); and Khanna, Quimio and Bojilova (1998)). Possible explanations for this negative reaction include anticipation of high future costs such as abatement and law suits (Khanna et al. (1998)); anticipation of green consumerism and anticipation of government regulation (Harrison and Antweiler (2003)).

Voluntary environmental efforts can be justified by a variety of reasons. First, over-compliance can improve the company’s reputation and climate change risk profile which can increase company value (Konar and Cohen (2001)). Similarly, a company with the best clean technology can impact future environmental standards in the industry and thus raise rivals’ costs. Second, a company with a clean technology competitive advantage may overcomply to signal to the government that compliance is not costly and thereby encourage tighter regulation (Denicolo (2008)). Third, a company may wish to overcomply in order to pre-empt tighter regulation (Maxwell, Lyon and Hackett (2000)). Fourth, the company may be succumbing to pressure from some group (Kim and Lyon (2008)). Investor reaction to voluntary efforts however, depends on how these actions are interpreted. With respect to carbon emissions, there are direct costs associated with
tracking and disclosing, and this cost may be viewed as unnecessary by those who believe tighter regulation to be unlikely. In particular, expenditures on environmental protection may displace other more productive investments and be detrimental to shareholder value maximization (Palmer, Oates and Portney (1995), Fisher-Vanden and Thorburn (2008)).

The literature suggests that investor reaction to voluntary overcompliance, such as disclosing carbon emissions, is contingent on the likelihood of regulation. In a state of high regulatory threat voluntary overcompliance is arguably a good signal regardless of the motivation behind it as overcompliance suggests that the company is better prepared for tighter regulation. In a state of low regulatory threat, any voluntary overcompliance may be viewed as a needless cost. It is possible that altruistic ‘green’ investors may value overcompliance for its own sake, but the proportion of green investors has been estimated to be less than 10 percent and not large enough to impact company decision making (Heinkel, Kraus and Zechner (2001)). This estimate of less than 10 percent is dated however, and the proportion of green investors has likely increased greatly since then. Heinkel et al. (2001) indicate that the proportion of green investors would need to be at least 20 percent to induce some polluting firms to reform. It is possible that the proportion of green investors is approaching (or surpassing) this 20 percent level. In 2010, one study found that almost one out of every eight dollars under professional management in the U.S. was involved in a socially responsible investing strategy (USSIF (2010)). Still, the likelihood of tighter regulation is an important factor in understanding investor response to carbon emissions disclosure, but it is unobservable and opinions are likely to vary.

To better understand investors’ reaction to companies that voluntarily overcomply in an uncertain legislative (or regulatory) environment, I develop a signaling model where companies can choose between two discrete signals (disclosure and nondisclosure), and where investors are uncertain about future legislation in addition to company type. Company type refers to the climate change profile of the company and the company’s pre-
Chapter 1. Introduction

paredness for future legislation. One example of two companies in the same industry that have a different climate change profile would be American Electric Power, which has an estimated 117 percent of EBITDA (earnings before interest, taxes, depreciation and amortization) at risk from carbon costs and PG&E, which has an estimated 2 percent of EBITDA at risk from carbon costs, based on 2009 estimates of the market price for carbon in a 2012 emissions trading scheme (Trucost (2009)). In this model, the company is more informed about their own type as well as the likelihood of legislation. Investors can potentially infer company type from the signal that the company chooses, and infer if future legislation will occur from the composition of signals in the market. For example, if the ratio of the number of companies that disclose to the total number of companies is sufficiently high, then investors infer that climate change legislation will occur.

The good signal (disclosure) is costly - there is a direct administrative cost of tracking emissions and auditing the information. A good-type company (i.e. prepared for future legislation or have low emissions) that believes there is a high likelihood of legislation will choose to disclose in order to reveal itself to investors. On the other hand, disclosure is prohibitively costly for bad-type companies and companies that believe that climate change legislation is unlikely. The prediction of this model is that if the proportion of companies that disclose to is sufficiently high, then a company’s stock price will increase when it chooses to disclose. If the reverse is true, the implication is that investors found the proportion of companies that disclosed to be low and hence that climate change legislation will not occur. That is, investors devalue companies that disclosed because disclosure is costly and uninformative when climate change legislation is unlikely.

I estimate the signaling model empirically using data from the 2006 Carbon Disclosure Project (CDP) where 280 publicly-traded Canadian companies were surveyed and asked to disclose their 2005 carbon emission levels. I use methods employed by Acharya (1988) and estimate the decision to disclose using a probit model where the covariates are in investors’ prior information set and proxy for investors’ expectation about a company’s
incentive to disclose. The probit model assumes the error term follows a standard normal distribution, and in this case represents companies’ private information. I calculate the selection hazard, also known as the inverse mills ratio, using the estimated parameters from the probit model. The selection hazard is the ratio of the probability density function over the cumulative density function of investors’ expectation about the company’s incentive to disclose. Using the estimated selection hazard for each company and a measure of its normal stock returns (i.e. returns that would have occurred in absence of the event, where the event is a voluntary carbon disclosure survey) as covariates, I estimate a generalized least squares (GLS) panel regression of the actual stock returns during the trading days following the signals. I test whether the coefficient on the selection hazard is greater than zero as this represents a test of the signaling model prediction that the market price of a stock increases if the company discloses and the ratio of the number of companies that disclosed to the total number of companies is sufficiently high.

Results from the probit or first-stage estimation indicate that company size, if the company reported carbon emissions to the government, and the company’s environmental performance score all increase the likelihood to disclose. Interestingly, the proportion of the company owned by CDP signatories is found to be insignificant. This result suggests that on average companies are not pressured by large investors into disclosing. Kim and Lyon (2008) stated that the possibility of companies not being pressured by large investors into CDP participation would be hard to argue. In their research however, the definition of participation included qualitative statements without disclosure of emissions information. I agree that companies could be easily pressured into giving qualitative statements, as this option is of low cost and low commitment.

Results of the second-stage GLS regression over a ten-day event window indicate that the mean daily abnormal return from disclosing is about -11 basis points, and the mean daily abnormal return from withholding is about 3 basis points. This result implies that investors believed that the likelihood of regulation was low, and is supported by
the fact that only 48 (17%) of the 280 companies surveyed by the CDP responded with emission levels information. In addition, the level of emissions disclosed is found to have no impact on abnormal stock returns. The implications of this analysis support the notion that a voluntary program alone may not be sufficient to achieve environmental objectives, however it has been found that a voluntary program combined with a threat of new environmental law may be effective (Brouhle, Griffiths and Wolverton (2009)). Response to this type of threat by investors as well as companies will determine its effectiveness as a policy tool.

To better understand companies’ responses to legislative threat, I model a company’s choice of carbon emissions level as a function of a company’s belief about legislative threat. In the model, there are two companies and one government. The companies choose between reducing emissions and polluting, and the government chooses between legislating and doing nothing. The companies decide whether or not to pollute based on their belief about the likelihood of government legislation, which is increasing in the current economic climate. That is, recession decreases the likelihood of legislation. In situations where the likelihood of legislation is high enough, companies choose not to pollute in order to avoid the risk of incurring the extra cost associated with the existence of legislation.

I also estimate the effect of green legislative threat during a period of economic decline. The methods I employ in this dissertation are related to Konar and Cohen (2001), where the authors investigate the effect of environmental performance on market value using various measures of environmental performance and Tobin’s Q as a measure of company value. I examine the effect of legislative threat on company value, as well as the interaction between the economic climate and the legislative threat. I use quarterly data on a balanced sample of U.S. publicly-traded companies from Q4 2006 to Q3 2010. The event of increased legislative threat is when Barack Obama became president-elect of the U.S., as part of his campaign was to begin an emissions trading scheme. His election occurred
during a time of recession (fourth quarter of 2008). I employ difference-in-differences methodology to estimate how the depth of a recession can impact the legislative threat effect on company value, using non-carbon-intensive industries as a control group. The results indicate that carbon-intensive companies were initially negatively impacted by the increased legislative threat, but this effect reversed as the depth of the recession became more apparent. I find that on average legislative threat of an emission trading scheme initially reduced Tobin’s Q by 18%. Once the extent of the recession is realized however, the legislative threat effect is eliminated. The results suggest that legislative threat may be ineffective as a policy tool (in the sense of a credible threat) during periods of economic decline.

It is important to consider how different companies would be affected by an emissions trading scheme. An emissions trading scheme is a market-based approach to controlling pollution that exploits differences in the costs of abatement across companies. The government places a limit on the amount of total emissions, and this limit is fractioned into permits which can then be allocated or auctioned to companies and which represent the right to emit a certain amount of greenhouse gases. Companies that need to increase their emission levels must buy permits from companies that have spare permits. Depending on how permits are allocated, it is possible that some companies that pollute less would have pollution permits to sell. Additionally, some companies will be able to reduce emissions at a low cost (i.e. have a relatively flat marginal abatement cost curve) so that reducing emissions to below their permitted level and then selling the excess permits is profitable. Companies that find it very costly to reduce emissions to the cap level can instead purchase permits at a lower cost. Thus to some extent, a trading scheme can be mutually beneficial - low-pollution companies sell permits at a profit, and high-pollution companies buy permits to comply with regulation more economically than by reducing emissions. In comparison to an environment without a trading scheme however, high-pollution companies are worse off. It is possible that some low-pollution companies may
be better off if they are allocated excess permits, or if they can reduce their emissions more cheaply than they can sell excess permits for.

Assuming that investors have knowledge of the carbon profile of companies, then there could exist some carbon-intensive companies that see an increase in their stock price during a credible legislative threat event. To check this possibility, I separate the group of treated companies into two subgroups: ‘good’ (i.e. low carbon emissions) companies which may be in a position to benefit from an emissions trading scheme, and ‘bad’ (i.e. high carbon emissions) companies which may be in a position to lose, and estimate the same difference-in-differences regression. I find that the average legislative threat effect is negative for good companies as well as bad, although it is less negative (by a significant amount) for the good companies. This result could be because investors are generally uninformed about the carbon emissions status of companies, or that investors believe that an emissions trading scheme will be costly to all companies in the industry.

This dissertation proceeds as follows: The remainder of Chapter 1 describes the regulatory and legislative environment in Canada and the U.S. and also discusses the literature. Chapter 2 outlines the theoretical framework. Chapter 3 describes the methodology for examining the financial market response to voluntary environmental overcompliance and Chapter 4 describes the methodology for examining the financial market response to legislative threat of an emissions trading scheme. Chapter 5 concludes.

1.2 The Regulatory and Legislative Environment in the U.S. and Canada

Legislation and Regulation

There are two main types of environmental law. One is legislation - created by legislature (i.e. a deliberative assembly) and passed by federal or provincial/state governments.
The other type of environmental law is regulation, which is a legal restriction from a government authority that describes how legislation will be implemented. The threat of broad-based and significant climate change policy has historically been legislative (as opposed to regulatory) in the U.S. and Canada. Regulation of other types of air pollution however has existed in both countries for many years.

In the U.S., the Clean Air Act of 1970 was the first federal legislation regarding government control of emissions. This legislation authorized the development of comprehensive federal and state regulations for the purpose of limiting emissions, and the U.S. Environmental Protection Agency (EPA) was established in part to implement the requirements of this Act. Since then, the EPA has been responsible for a variety of Clean Air Act programs to reduce air pollution, and amendments to the Clean Air Act have increased programs and expanded enforcement authority.

Current laws on toxic emissions may provide insight into the nature of how governments in the future may choose to limit carbon emissions. In 1986 the EPA initiated a program known as the toxics release inventory (TRI). The TRI requires manufacturing facilities with ten or more employees and producing or using above a threshold amount of chemicals to report the annual releases of these chemicals to the EPA. The EPA provides the disclosed emissions information to the public through the TRI database. The initial release of this information was in June 1989, with 1987 pollution figures.

The TRI lists over 600 substances but does not include greenhouse gas emissions. In June 2009 however the EPA, through the Clean Air Act, found that carbon dioxide and five other greenhouse gases constitute a threat to public welfare and that emissions from vehicles contribute to climate change. This ‘endangerment finding’ allows the EPA to regulate greenhouse gases under existing provisions of the Clean Air Act.

In Canada air pollution falls under the Canadian Environmental Protection Act (CEPA). Introduced in 1985 and last updated in 1999, this Act provides a framework for management and control of toxic emissions at each stage of the emissions life cycle and in
particular allows for entering into intergovernmental environmental agreements. Similar to the U.S. process, for a substance to be subject to the requirements of CEPA, Cabinet must pass a regulation designating it as toxic. In Canada, Cabinet has yet to designate greenhouse gases as toxic as of the writing of this dissertation.

Similar to the TRI, Canada has publicly available data on facility-level toxic emissions known as the National Pollutant Release Inventory (NPRI). The information reported by facilities is published by Environment Canada under the authority of CEPA 1999. Separate from the NPRI, Canada also has a program for manufacturing facilities to report high levels of greenhouse gas emissions known as the Greenhouse Gas Emissions Reporting Program (GHGRP). Initiated in 2004, this program applies only to the largest industrial greenhouse gas emitters - facilities that emit 100,000 tonnes\(^3\) of carbon dioxide equivalent or more annually - and requires them to disclose carbon emissions information by June 1st of the following year. Other facilities can choose disclose this information voluntarily. This emissions data becomes publicly available about five months later. The EPA also has a GHGRP to collect greenhouse gas emissions data for the purpose of informing future policy decisions, though it was initiated much later in October 2009. Facilities in certain industry groups are required to report 2010 emissions by September 2011.

Both Canadian and U.S. regulations are based on the Best Available Technology (BAT) regime. BAT in this case refers to the most advanced development of processes, facilities or methods of operation which indicate the practicality of a policy for limiting emissions. For example, one jurisdiction may choose to change emission limits for certain substances based on the demonstrated performance capabilities of an economically feasible BAT in another jurisdiction. Currently, the EPA has authority to enforce greenhouse gas limits and can force some newly built or modified sources of industrial pollution to use the BAT to limit their carbon emissions.

With the exception of the recent developments in EPA regulation, broad-based climate

\(^3\)In 2010 (for 2009 emissions data) for all facilities this minimum was reduced to 50,000 tonnes.
change policy has historically been a legislative threat in the U.S. and Canada. As well, the likelihood of such legislation has seemed to vary substantially over the last several years. In 1997, Canada and the U.S. agreed to the Kyoto Protocol to reduce greenhouse gas emissions, with a plan to come into force by 2005. Although the U.S. proposed an emissions trading scheme for Protocol implementation, the country never ratified the agreement, and in 2001 withdrew altogether. Canada did ratify the agreement, but ceased participation in 2006 as a result of a change in government and instead focused on programs to reduce the intensity of emissions.

In November 2008, Barack Obama became president-elect of the U.S., and his platform included introducing an emissions trading scheme. Shortly after this election, the Canadian government announced that it would participate with the U.S. in such a system. In June of 2009, this threat became stronger when the American Clean Energy and Security Act bill, which included cap-and-trade\footnote{Cap-and-trade is a commonly used term to describe a system where emissions are capped at a certain level, and emission permits are allocated (in some cases, by auction) to firms who may trade the permits amongst themselves in order to achieve their own objectives.} was approved by the House of Representatives. By July 2009 however, the threat of regulation once again weakened, as the U.S. Senate reported that it would not consider climate change legislation before the end of the legislative term.

Changes in political leadership can impact the likelihood of legal action on climate change, as was the case when Barack Obama became president-elect. In Canada in 2006, it is possible that there may have been a decrease in the likelihood of legal action on carbon emissions because a change in government ended the country’s participation in the Kyoto Protocol. It is arguable however, that even before the change in government the likelihood of legal action on carbon emissions in Canada was low simply because the U.S. was not participating in the Kyoto Protocol.
Regional Initiatives

At the state-level, pollution laws must be at least as strong as the national regulations under the Clean Air Act. Certain U.S. states and Canadian provinces have implemented carbon taxes including British Columbia, Alberta, Quebec, Colorado, California and Maryland. As well, California has a law capping emissions, but has not been involved in emissions trading. Some jurisdictions have taken efforts to develop their own programs to reduce carbon emissions in lieu of federal action. There are three such programs in particular. One is the Regional Greenhouse Gas Initiative (RGGI), which was the first to attempt an emissions trading scheme in North America. The RGGI participant states consist of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. Incorporated in 2007, this group began emissions trading for power plants in September 2008.

Another program is the Western Climate Initiative (WCI). The WCI began in February 2007 with an agreement among the Governors of Arizona, California, New Mexico, Oregon, and Washington. The purpose of the WCI is to reduce greenhouse gas emissions in the region through an emissions registry and a market-based program. The design for the WCI Regional Program was announced in July 2010 and it describes the emissions trading scheme planned to begin in January 2012. This comprehensive program will cover nearly 90 percent of the greenhouse gas emissions in WCI participant jurisdictions once fully implemented in 2015 (Western Climate Initiative (2011)). In addition to the original five, participating jurisdictions include British Columbia, Manitoba, Ontario, and Quebec, Montana and Utah.

The third program is the Midwest Greenhouse Gas Reduction Accord (MGGRA). The MGGRA was signed in November 2007 and represents a commitment by the governors of six Midwestern states and the premier of one Canadian province to reduce greenhouse gas (GHG) emissions through a regional cap-and-trade program and other complementary policy measures. Members include Illinois, Iowa, Kansas, Manitoba, Michigan,
Minnesota and Wisconsin. The Accord commits participating jurisdictions to establish a greenhouse gas reduction program. As part of this program, members of the Accord will set regional greenhouse gas emission reduction targets and develop a multi-sector cap-and-trade system and complementary policies to help achieve these targets.

Voluntary Initiatives

There have also been several local and international programs that have been created with the purpose of encouraging companies to reduce their carbon emissions or their emissions intensity. In particular, the Carbon Disclosure Project (CDP) was created in 2002 as a non-profit organization and a collaboration of institutional investors that would seek out carbon emissions information from companies and collect it in a database. In 2006, the CDP represented 225 international institutional investors (known as signatories) with a total of $31 trillion U.S. dollars in assets under management. That same year was the first year that the CDP survey was sent to many Canadian (and American) companies requesting voluntary disclosure of their annual carbon emission levels. Participation in the survey was voluntary and the CDP released information to the public in September 2006. The survey asked for both quantifiable information (yearly emissions) and unquantifiable information on the climate change risk of the company.\footnote{The questionnaire can be found in the Appendix, section 6.3, and in the Canadian CDP4 report, available online at: \url{https://www.cdproject.net/CDPResults/CDP4_Canada_Report.pdf}} In addition, companies can disclose both or either of direct or indirect emissions. Indirect emissions are those from supply chain and product and service use rather from owned and controlled facilities.

Another example of a voluntary program is Climate Leaders - a U.S. industry-government partnership that has been working with companies since 2002 to develop comprehensive climate change strategies. Companies choosing to participate in the program are required to develop a carbon emissions management system and set aggressive
reduction targets. Progress of the company is reported to the EPA annually, and over time the company develops a credible record of environmental performance. Successful companies are recognized by the EPA as corporate environmental leaders.

Given that climate change is a global issue, as well as the economic relationship between Canada and the U.S., it is not surprising that carbon emissions policies and programs in Canada and U.S. have been linked. Most likely this consistency is beneficial as it would aid transition to a global framework. However, federal actions on climate change have been lagging regional initiatives. It is possible that political issues have delayed a comprehensive North America-wide climate change policy (Getting Warmer (December 5, 2009)). It is possible that incentive programs and regional actions could replace federal efforts if they are coordinated. Regional initiatives seem to currently be progressing faster than broader-based programs, however some regions with a fair amount of polluting companies may be slow to adopt changes.

1.3 Literature Review

Overview

For financial markets to be a viable mechanism for improved company environmental performance they must reward good environmental behaviour and punish poor behaviour to an extent that invokes change. Heinkel et al. (2001) develop a framework where a segment of the investor population avoids investing in a company that excessively pollutes such that less risk-sharing among the remaining investors leads to a lower company stock price and an increased cost of capital. If this cost increases to be more than the cost of improving environmental performance to an acceptable level, then a polluting company would reform. This framework illustrates the potential for financial markets to encourage environmental performance, but the incentive for investors to act in this manner is unclear.
Investor Motivations for Encouraging Overcompliance

There are several reasons why an investor may value environmental performance. One such reason is altruistic, where the investor derives utility simply from investing in a company that is environmentally friendly. The increase in the number of socially responsible investment funds suggests that the number of these investors is growing, however the proportion of ‘green’ investors has been estimated to be less than 10 percent and not large enough to impact company decision making (Heinkel et al. (2001)). This estimate of less than 10 percent is dated however, and the proportion of green investors has likely increased greatly since then. Heinkel et al. (2001) indicate that the proportion of green investors would need to be at least 20 percent to induce some polluting firms to reform. It is possible that the proportion of green investors is approaching (or surpassing) this 20 percent level. In 2010, a one study found that almost one out of every eight dollars under professional management in the U.S. today was involved in some strategy of socially responsible investing (USSIF (2010)).

For investors motivated only by financial gain, some may associate future costs to current high levels of pollution. To determine investor reaction to reports of high levels of pollution, specifically toxics emissions, several event studies have been conducted (See Hamilton (1995); Konar and Cohen (1997); and Khanna et al. (1998).). These studies use the U.S. Environmental Protection Agency (EPA) toxics release inventory (TRI) data to illustrate how this information creates incentives for companies to improve their environmental performance. Each of the studies on the investor reaction to this TRI information sought to determine if this information was unanticipated by investors, and if so how investors responded to this data. To do so, each study employed the market model to estimate a measure of predicted returns in absence of the event, a method suggested by Brown and Warner (1985). Each study also employed some method of cross-sectional analysis to examine the effect of the emission levels on the change in market value. Hamilton (1995) found that companies that reported TRI pollution had an
average loss of $4.1 million in market capitalization on the day the figures were released, suggesting that investors found TRI data to be informative. Konar and Cohen (1997) and Khanna et al. (1998) had similar results, and also went further to investigate the effect of the stock market reaction on subsequent company behaviour. Konar and Cohen (1997) found that companies with the largest stock price decline on the public release of the information later reduced emissions more than comparable companies in their industry. Similarly, Khanna et al. (1998) found that market losses led to reduced on-site toxic releases and increased wastes transferred off site, although the effect on total emissions generated by the companies was negligible. Whether or not toxics emissions were reduced, the negative investor response to toxics emissions information is clear.

To explain the negative stock market reaction to toxic emissions information, it has been suggested that investors foresee future costs (abatement, law suits, etc.) associated with high levels of toxic emissions (Khanna et al. (1998)). Harrison and Antweiler (2003) call attention to the fact that these studies do not consider the various possible motivations of investors, and assert the possibility that investors act at least partially in anticipation of government regulation, rather than wholly in place of it. Further, Antweiler and Harrison (2003) examine the extent to which green consumerism spurred by toxic emissions data is effective at reducing emissions. In other words, they examine the extent to which green consumerism in response to the Canadian National Pollutant Release Inventory (NPRI) is a substitute for government regulation. The authors construct a measure of the extent to which companies are subject to intra-company spillover effects, where a high-emission sector may negatively impact sales in a low-emission sector assuming that consumers use the NPRI to identify companies (not particular products) with high-emissions facilities. They also construct a measure of exposure to consumer markets. These variables and their interaction are then used in fixed-effects regressions employing various measures of emission levels as dependent variables. Although statistically significant, the effect of green consumerism is found to be weak. The authors also
point out that it is unclear whether the indirectly-measured effect of green consumerism is from actual pressure or just pressure anticipated by companies.

Similar explanations can certainly be made for investor reaction to carbon emissions information. Any negative investor reaction to high levels of carbon emissions may be motivated by climate change risk, anticipated green consumerism, anticipated government regulation, and so on. There are a variety of reasons to explain negative investor reaction to high levels of carbon emissions. It is also important to consider however, possible explanations for investor reaction to the decision to voluntarily disclose carbon emissions as this represents an act of overcompliance.

Although overcompliance is good from an environmental perspective, investors may view it negatively. It has been suggested that expenditures on environmental protection may displace other more productive investments (Palmer et al. (1995)). In particular, a recent study found that companies announcing membership in a program related to climate change, Climate Leaders, experience significantly negative abnormal stock returns (Fisher-Vanden and Thorburn (2008)). This effect was found to be smaller in carbon intensive industries where the likelihood of regulatory actions are higher, and for high book-to-market value companies, suggesting that ‘green’ expenditures displace growth-related investments. The authors employ Heckman-type methods to account for self-selection since companies choose to join these programs. Fisher-Vanden and Thorburn (2008) argue that voluntary environmental initiatives are detrimental to shareholder value maximization. In the U.S., there was a negative stock market reaction to membership in Climate Leaders (an American program) and no reaction to membership in Ceres, a program with less-stringent qualifications.

In summary, the literature suggests that financially motivated investors may respond to anticipated legislation and value company actions of environmental overcompliance. Lack of credible legislative threat however may cause investors to devalue overcompliance as an unnecessary cost.
Company Motivations for Overcompliance

There are several reasons why a company might choose to overcomply with regulation. A company may choose to overcomply due to pressure from some group, such as a large institutional investor and in particular pension funds which have long time horizon for investing (Kim and Lyon (2008)). For example, the Carbon Disclosure Project (CDP) is an organization of institutional investors that may engage in activism. Such activism may explain why environmental performance has been found to be positively correlated with the intangible asset value of companies. After controlling for variables traditionally thought to explain company-level financial performance, Konar and Cohen (2001) conclude that legally emitted toxic chemicals have a significant negative effect on the intangible asset value of publicly traded companies. Another reason companies may choose to overcomply is to attract green consumers/investors. Not all investors may appreciate overcompliance however, as was found to be the case with Climate Leaders (Fisher-Vanden and Thorburn (2008)).

It is unclear why managers chose to join voluntary environmental programs if investors react negatively. Perhaps managers do so because they believe it improves their reputation and climate change risk profile, something that is value-enhancing, as suggested by Konar and Cohen (2001). Considering voluntary disclosure as an act of overcompliance, there are a few overlapping socio-political theories to explain this action including legitimacy theory and stakeholder theory (Patten (2002)). These similar theories suggest that disclosure is a function of social and political pressures facing the company, such that a company will choose to disclose in order to change public perception of the company (Clarkson, Li, Richardson and Vasvari (2008)). Regardless, Fisher-Vanden and Thorburn (2008) provide evidence that participation in voluntary environmental programs leads to negative investor reaction, possibly due to a lack of regulatory threat.

Stronger regulatory threat may cause investors to react positively to environmental overcompliance. Kim and Lyon (2008) use CDP data to determine if corporate partici-
Participation in the CDP affects stock prices, particularly when there is a stronger regulatory threat. Using international data from four years of CDP surveys and employing event study methodology, the authors found an increase in market value for companies that participated in the CDP after Russia ratified its Kyoto protocol, but only for companies based in countries that had yet to ratify their Kyoto protocol. In this case, Russia’s ratification of its Kyoto protocol was argued to increase the regulatory threat in the other countries that had not ratified their protocol. As a result, the authors conclude that participation in the CDP, even when the company only discloses some qualitative information, increases a company’s stock price when the likelihood of regulation is high. Results from both Fisher-Vanden and Thorburn (2008) and Kim and Lyon (2008) suggest that the current regulatory environment and the anticipated future regulatory/legislative environment will play a large role in determining investor reaction to voluntary environmental overcompliance.

The regulatory or legislative environment can motivate companies to overcomply with current rules. Overcompliance as a response to regulatory or legislative threat has been modeled in two general ways: as a signal to encourage tighter regulation or as a way to pre-empt regulation. A company may want to encourage regulation if the company has a competitive advantage, such as the use of a cleaner but more costly technology. Denicolo (2008) models company overcompliance as a signal to the government that compliance is not costly so as to cause the government to tighten regulations. The author references direct evidence where certain overcomplying companies such as DuPont have called for stricter regulation. Similarly, a company with the best clean technology can impact future environmental standards in the industry and thus raise rivals’ costs due to the Best Available Technology (BAT) basis of environmental regulations in the U.S. and Canada (See section [1.2]).

Conversely, a company may wish to pre-empt regulation in order to prevent the costs associated with tighter regulation. Maxwell et al. (2000) model self-regulation and
social welfare in a three-stage game where Cournot oligopolists face the possibility of stricter pollution abatement regulations, and this causes companies to voluntarily reduce emissions. The authors examine empirically the state-level variation in the threat of regulation on releases of toxic chemicals over the period 1988-1992, where the threat of regulation is measured by conservation group membership per capita in each state, among other measures. The authors find that states with high initial levels of emissions (low marginal cost of abatement) and larger regulatory threat reduce emissions more rapidly. All measures of state political climate however, were found to be insignificant and so the authors claim that it is unclear how pressure is transmitted. This pressure may have come directly from the conservation groups or perhaps investors.

There are a variety of motivations a company may have to voluntarily overcomply with regulations, mostly financial. As a result it seems reasonable to consider financial markets as a mechanism for overcompliance.

**Credibility**

The literature suggests that the regulatory or legislative environment can motivate companies to improve their environmental performance. Using a game-theoretic model, Segerson and Wu (2006) show that a policy that combines a voluntary approach to reducing nonpoint-source pollution with a threat of an ambient tax if the voluntary approach is unsuccessful can induce cost-minimizing abatement. In addition, it has been found empirically that the threat of regulation on the metal-finishing industry in the U.S. caused companies to reduce emissions (Brouhle et al. (2009)). The proportion of a facility’s emissions stemming from chemicals subject to regulatory threat was found to have a positive effect on the decision to participate in the voluntary Strategic Goals Program - a program designed to reduce emissions. Regulatory threat was also found to lead to emission reductions. The authors also found evidence that facilities reacted strongly to both the initial threat of regulation and to an increase in its relative stringency. Although
the credibility of the regulatory threat in their study is not discussed, they do emphasize that the regulatory threat analyzed is indeed credible, even though the regulation never did come to pass.

In addition to being credible, it has been found that regulatory threat must also not be too strong to be effective, otherwise companies will just wait for the regulation to occur and benefit from not paying abatement costs sooner (Antweiler (2003)). The author develops a model in which companies determine their own abatement levels based on certain factors relating to environmental risk exposure. In particular, the company-level characteristics that are said to determine abatement effort caused by regulatory threat are the volume of emissions, the toxicity of the emissions, the extent to which the emissions are a danger to the public, unabated pollution intensity, unit abatement cost, and the company’s position to relative to other companies (regulatory threat is only effective if companies do not free-ride on other companies’ abatement efforts). Empirically, these company-level characteristics are used to back-out the effect of regulatory threat on company-level emissions. Results from the time-differenced toxic emission regressions suggest that the effect of green regulatory threat was small in Canada during 1993 to 1999, though the author states the empirical work is not entirely conclusive.

Success of a regulatory or legislative threat is contingent on its credibility. The distinction between legislative and regulatory threat is an important one in this context. Legislative threat is influenced more by political pressures, and there is evidence that governments delegate their legislative responsibilities to somewhat independent specialized institutions (i.e. regulatory bodies) in order to increase credibility (Gilardi (2002)). Periods of economic decline may affect the credibility of the government when threatening a type of legislation that negatively impacts companies. Historically in Canada and the U.S., the threat of climate change regulation has been legislative (See section 1.2).

The literature does not provide a clear prediction of how investors may react to the voluntary disclosure of carbon emissions. If future climate change legislation is antici-
pated, then it possible that investors are going to value environmental overcompliance. If future climate change legislation is not anticipated or the threat is not credible, then investors may see overcompliance as an unnecessary cost.
Chapter 2

Theoretical Framework

2.1 Model of Overcompliance as a Signal of Company Value

2.1.1 Overview

To better understand investors’ reactions to companies that voluntarily overcomply in an uncertain legislative environment, I develop a signaling model in the spirit of Acharya (1988) as guidance for my empirical analysis. In my model, companies can employ one of two discrete signals, disclosure and withholding, and investors derive information from the individual signal and from the composition of signals in the market. I assume that there are no altruistic motivations for disclosing carbon emissions.

Players and Actions: Consider a game with a continuum of companies $i \in I$ and a representative investor. The companies must each choose between two actions: (i) to disclose their carbon emission levels, $d$, or (ii) to not disclose, $n$. The investor prices the stock of each company by conditional expectation of the future (or true) value per share given all their information.
**Information:** Each company receives a random draw of private information that is one of two possible messages about future legislation: \( m = 0 \) (there will be no legislation) and \( m = 1 \) (there will be legislation). Let \( \Phi \) represent the future state, where \( \Phi = 1 \) when there is legislation and 0 otherwise. The company’s message about future legislation is noisy but conditionally correct, i.e. \( \Pr(m = \phi \mid \Phi = \phi) = q \in (\frac{1}{2}, 1) \). Each company knows its type, which is one of two possible types: \( \tau = G \) (the company is a good type) and \( \tau = B \) (the company is a bad type). These types refer to the company’s preparedness for tighter legislation and the company’s carbon emission levels.

The investor is uncertain about the future state of legislation and about each company’s type. The priors over \( \tau \) and \( \Phi \) are assumed to be neutral. The investor knows ex-ante the quality of the message received by companies \( q \).

**Timing:** First companies receive their draws of private information. Next, the companies move simultaneously and choose a signal. The investor then derives information about the future state \( \Phi = 1 \) from the ratio of the number of companies that disclosed to the total number of companies \( \varsigma \), and derives information from the company’s signal \( s \in \{d, n\} \) about the company’s type \( \tau \in \{G, B\} \). The investor then prices each company’s stock by conditional expectation of the future value per share of the company. In the future both the state and the true value of each company’s stock is realized.

**A Company Payoff:** A company’s payoff is the sum of (i) the company’s current (after signal) stock price \( P_t(s, \varsigma) \), which depends on its choice of signal and the signals of other companies, and (ii) the company’s future (true) stock price \( v(s, \tau, \Phi) \), which depends on its choice of signal, company type and if legislation is in place. That is,

---

1Investors are likely to have opinions about future regulation and not be “neutral”. I model the investor’s prior as neutral based on the idea that investors believe that managers are more knowledgeable about the likelihood of future legal action on carbon emissions since it is in management’s best interest to be knowledgeable on this topic as it directly affects their company. In my model, the representative investor waits to see what management does before forming an opinion.
The company’s payoff can be represented as

\[ P(s, \varsigma) + v(s, \tau, \Phi) . \]  

(2.1)

The expected future value per share of a company post-signal is

\[ P(s, \varsigma) = E[v(s, \tau, \Phi) \mid s, \varsigma] , \]  

(2.2)

which can be expanded to:

\[
P(s, \varsigma) = \sum_{\tau, \Phi} v(s, \tau, \Phi) \cdot \Pr(\tau, \Phi \mid s, \varsigma) \\
= v(s, G, 1) \cdot \Pr(\tau = G, \Phi = 1 \mid s, \varsigma) + v(s, B, 1) \cdot \Pr(\tau = B, \Phi = 1 \mid s, \varsigma) + \\
v(s, G, 0) \cdot \Pr(\tau = G, \Phi = 0 \mid s, \varsigma) + v(s, B, 0) \cdot \Pr(\tau = B, \Phi = 0 \mid s, \varsigma).
\]

Figure 7.1 illustrates that there are eight possible true values for a company; four values for each choice of signal. The investor is risk neutral and makes zero expected profits.

2.1.2 Equilibrium

My overall objective is to specify conditions for a (semi-) separating equilibrium. The possible future values of a company are related through the following conditions. First,

\[ v(n, G, 1) - v(d, G, 1) = v(n, G, 0) - v(d, G, 0) > 0 \]  

(2.3)

which means that disclosure is costly for a good-type company, and this cost is the same regardless of the state. Second,

\[ v(n, B, 1) - v(d, B, 1) = v(n, B, 0) - v(d, B, 0) > v(n, G, 0) - v(d, G, 0) \]  

(2.4)
which means that disclosure is more costly for a bad-type company than a good-type company and again is the same across states. The intuition behind a higher cost of disclosure for a bad-type company is that such companies may not track their carbon emissions or have any plan in place to reduce carbon emissions. Good-type companies are more likely to already be tracking carbon emissions for their own purposes and thus have little to no additional cost to disclose this information. Third,

\[ v(n, B, 0) = v(n, G, 0) \quad (2.5) \]

which means that company type does not affect company value when the company does not disclose and there is no legislation. The intuition for this condition is that investors do not value actions to reduce carbon emissions in a state without legislation. Last,

\[ v(d, B, 1) < v(d, G, 1) \]
\[ v(n, B, 1) < v(n, G, 1) \quad (2.6) \]

which means that given \( s \), when there is legislation the value of the good-type company is greater than the bad-type company.

For existence of a semi-separating equilibrium, the company’s true value per share must meet a technical condition, specifically, I assume

\[ \frac{3}{2} v(n, B, 1) - v(d, B, 1) > v(d, G, 1) = \frac{1}{6} v(n, B, 1) + \frac{5}{6} v(n, G, 1) \quad (2.7) \]

is satisfied.
Theorem 2.1.1 (Existence) \(\text{Given assumptions (2.3) - (2.7), and the investor’s and companies’ decision rules, there exists a semi-separating equilibrium such that companies’ and the investor’s actions and beliefs are together consistent with Bayes’ rule, and where}\)

1. if a company receives message \(m = 1\) and is type \(\tau = G\), then the company discloses \((s = d)\), and

2. if a company receives message \(m = 0\) or is type \(\tau = B\), then the company does not disclose \((s = n)\).

The proof of existence of the equilibrium is in the Appendix, section (6.1). The equilibrium is not fully-separating because there are only two choices of signals whereas there are four categories of companies since companies receive messages about both company-type \((\tau \in \{G, B\})\) and future legislation \((\Phi \in \{0, 1\})\). Section (6.1.1) in the Appendix shows that (2.2) can be represented as

\[
P_t(s, \varsigma) = v(s, G, 1) \cdot \Pr(\tau = G \mid s, \Phi = 1) \cdot \Pr(\Phi = 1 \mid \varsigma) + \\
v(s, B, 1) \cdot \Pr(\tau = B \mid s, \Phi = 1) \cdot \Pr(\Phi = 1 \mid \varsigma) + \\
v(s, G, 0) \cdot \Pr(\tau = G \mid s, \Phi = 0) \cdot \Pr(\Phi = 0 \mid \varsigma) + \\
v(s, B, 0) \cdot \Pr(\tau = B \mid s, \Phi = 0) \cdot \Pr(\Phi = 0 \mid \varsigma) .
\]

The Equilibrium Pricing Rule

The investor uses \(s\) and \(\varsigma\) as inputs for valuing a company assuming a semi-separating equilibrium. Given the companies’ equilibrium strategies, the proportion of disclosures in the market \(\varsigma\) is informative about the state \(\Phi \in \{0, 1\}\), and a signal \(s \in \{d, n\}\) is informative about company type \(\tau \in \{G, B\}\). When the ratio of the number of companies that disclose to the total number of companies \((\varsigma)\) is sufficiently low, then the investor believes with probability 1 that the state is \(\Phi = 0\). When the ratio of the number of companies that disclose to the total number of companies \((\varsigma)\) is sufficiently high, then
the investor believes with probability 1 that the state is $\Phi = 1$ and that a company that issues signal $d$ is a good type ($\tau = G$). These beliefs, combined with the critical value of $\varsigma, \frac{q}{2}$, imply the following pricing rules

- if $\varsigma = \frac{1-q}{2}$ and a company chooses signal $n$ then that company’s stock price is $P \left( n, \varsigma = \frac{1-q}{2} \right) = v(n, G, 0) = v(n, B, 0)$, and

- if $\varsigma = \frac{1-q}{2}$ and a company chooses signal $d$ then that company’s stock price is $P \left( d, \varsigma = \frac{1-q}{2} \right) = v(d, G, 0)$, and

- if $\varsigma = \frac{q}{2}$ and a company chooses signal $n$ then that company’s stock price is $P \left( n, \varsigma = \frac{q}{2} \right) = v \left( n, G, 1 \right) - \frac{1-q}{2-q} v(n, B, 1)$, and

- if $\varsigma = \frac{q}{2}$ and a company chooses signal $d$ then that company’s stock price is $P \left( d, \varsigma = \frac{q}{2} \right) = v(d, G, 1)$.

The intuition for these rules are that if the ratio of the number of companies that disclose to the total number of companies ($\varsigma$) is sufficiently high then disclosure is a positive signal. If $\varsigma$ is low, then investors believe that there will be no legislation and hence that disclosure is unnecessary/uninformative. In this case, disclosure decreases a company’s value because disclosure is costly.

### 2.2 Model of Overcompliance as Preemption

#### 2.2.1 Overview

I model choice of carbon emissions level as a function of a company’s belief about the credibility of legislative threat. The following describes the mechanics of the model.

**Players and Actions:** Consider a two-stage game with three players: two companies $i = 1, 2$ and a government. Companies must choose between two actions: (1) reduce
emissions, 0, or (2) pollute, $p$. The government must also choose between two actions: (1) do nothing, $n$, or (2) legislate, $l$.

**Timing:** First the two companies move simultaneously. Next the government moves. The use of a one-period two-stage game can be supported by the fact that company emission levels can often be attributed to the manager’s choice of fixed assets and production technologies - a long-term commitment.

**Payoffs:** All players receive a payoff at the end of the game. Companies receive one of two possible payoffs. Company $i$ receives a payoff of $\pi_0$ if they choose to reduce emissions and $\pi_p$ if they choose to pollute, where $\pi_p > \pi_0$. That is, the high-pollution technology is cheaper to employ.

The government receives one of three possible payoffs. If both companies choose not to pollute, then the government receives a welfare payoff of 1. If both companies choose to pollute, then the government receives a payoff of 0. If one company chooses to pollute and the other does not, then the government receives a payoff of $\gamma$, where $\gamma \in (0, 1)$.

If the government legislates (chooses $l$) in the second stage, then a company that pollutes incurs a cost $c$ to offset this pollution, where $c \geq \pi_p - \pi_0$, and the government incurs a political cost of legislation, $\psi \in [\underline{\psi}, \overline{\psi}]$. The political cost $\psi$ is drawn from the distribution $F(\psi|\theta)$, where $\theta$ is the economic state $\theta \in [\underline{\theta}, \overline{\theta}]$. I assume that the family of distributions $F(\psi|\theta)$ is decreasing in $\theta$ in the sense of first order stochastic dominance $\forall \theta$. This assumption implies that as $\theta$ decreases (i.e. the economy worsens) the expected political cost of legislation increases, capturing the idea that legislation is less costly (at least in a political sense) when the economy is strong than when the economy is weak.

**Information:** Each player knows the possible payoffs and the state of the economy $\theta$. Companies however, do not know ex-ante what the other company will choose since emissions levels are chosen simultaneously. Companies also do not know the government’s political cost of legislation $\psi$, however the distribution $F(\psi|\theta)$ is commonly known. In the
second stage the government observes the draw of $\psi$, and all players know the pollution level each company chose. Figure 7.2 illustrates the game.

2.2.2 Equilibrium

I solve for the equilibrium using backward induction. The government moves in stage two, after observing its cost and the actions of both firms. My goal is to find a symmetric equilibrium in that both companies play the same strategy.

**Government's strategy**

When both companies reduce emissions, there is no incentive for the government to legislate and incur the associated cost. When one or both of the companies pollute, then it may benefit the government to legislate. The government’s decision rule is to legislate when the payoff from legislating is greater than the payoff from not legislating. Both payoffs are known with certainty when the government is making the decision. When only one company chooses $p$, then the government will legislate only if $1 - \psi > \gamma$. When both companies choose $p$, then the government will legislate only if $1 - \psi > 0$. These decision rules imply critical values of $\psi$ such that

- if $\psi < \psi^* = 1 - \gamma$, then the government legislates if at least one company chooses $p$;
- if $\psi < \psi^{**} = 1$, then the government legislates if and only if both companies choose $p$.

**A company’s strategy**

A company chooses a pollution level to maximize its payoffs, which are uncertain. Recall that a company does not know the government’s cost of legislating $\psi$, but does know the state of the economy $\theta$ and $F(\psi|\theta)$. A company updates its belief about $\psi$ after the economic state becomes known. A high value of $\theta$ indicates that the economy is strong and implies a higher likelihood that the political cost of legislation ($\psi$) is low - thus making legislation more likely. A company’s belief that the government will legislate
when only one company pollutes is given by $\Psi^* = \Pr[\psi < \psi^*|\theta]$. A company’s belief that the government will legislate if and only if both companies pollute is $(\Psi^{**} - \Psi^*)$, where $\Psi^{**} = \Pr[\psi < \psi^{**}|\theta]$. By definition $\Psi^{**} > \Psi^*$, and $\Psi^{**}, \Psi^*$ are both monotonically increasing in $\theta$ by the first order stochastic dominance ordering.

A company’s payoff from not polluting is $\pi_0$, and the company receives this payoff regardless of what the other players do. A company’s expected payoff from polluting, assuming the other company pollutes with probability $\rho \in [0, 1]$, is equal to

$$\pi_p - \rho(\Psi^{**} - \Psi^*)c - \Psi^*c,$$

which is the pollution payoff ($\pi_p$) less the probability that the other company pollutes ($\rho$) multiplied by the probability that the government legislates when both companies pollute ($\Psi^{**} - \Psi^*$) multiplied by the cost to offset the pollution ($c$), less the probability that the government legislates when only one company pollutes ($\Psi^*$) multiplied by the cost to offset the pollution ($c$).

When the other company pollutes with probability 1 (i.e. $\rho = 1$), the expected payoff from polluting is equal to $\pi_p - (\Psi^{**} - \Psi^*)c$. When the other company pollutes with probability 0 (i.e. $\rho = 0$), the expected payoff from polluting is equal to $\pi_p - \Psi^*c$. When the payoffs from polluting versus not polluting are equal, then the companies play a mixed strategy. Setting $\pi_0$ equal to expression (2.8) and solving for $\rho$:

$$\rho^* = \frac{\pi_p - \pi_0 - \Psi^*c}{(\Psi^{**} - \Psi^*)c},$$

where $\rho^*$ characterizes the mixed strategy equilibrium when $\rho^* \in (0, 1)$. Derivation of $\rho^*$ is in the Appendix, section (6.2).
Theorem 2.2.1 (Existence) For every $\theta$, given the government’s and company’s strategies, a perfect bayesian equilibrium exists and it is unique such that,

- if $\pi_p - \pi_0 \geq \Psi^{**}c$, then $\rho = 1$ and both companies pollute.
- if $\pi_p - \pi_0 \leq \Psi^{*}c$, then $\rho = 0$ and neither company pollutes.
- if $\Psi^{*}c < \pi_p - \pi_0 < \Psi^{**}c$, then $\rho^* \in (0, 1)$ (as in equation (2.9)) and each company plays a mixed strategy.

where $\Psi^{*} = \Pr[\psi < \psi^*|\theta]$ and $\Psi^{**} = \Pr[\psi < \psi^{**}|\theta]$.

Proof of the existence of the equilibrium is in the Appendix, section (6.2). Companies play a mixed strategy ($\rho^* \in (0, 1)$) when

$$\Psi^{*}c < \pi_p - \pi_0 < \Psi^{**}c. \quad (2.10)$$

That is, companies play a mixed strategy when the gain in payoff from polluting is less than the expected cost of polluting when both companies pollute but greater than the expected cost of polluting when only one company pollutes.

When companies play a pure strategy and choose to pollute, then in this case legislative threat is ineffective. When companies play a pure strategy and choose not to pollute, then in this case legislative threat is completely effective. I will focus on the mixed strategy equilibrium for further analysis to see how a change in the economic climate affects the probability that a company will pollute.

2.2.3 Comparative Statics

The focus of my empirical strategy is to understand how a change in economic growth affects the company’s choice of pollution level through their belief about the government’s political cost function. To simplify this exposition I assume that $\psi^* < \bar{\psi}$, which
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means \( \Psi^* = 0 \) and thus that \( \rho^* = \frac{\pi_p - \pi_0}{\Psi^{**}c} \). A positive value for \( \Psi^* \) implies that there is a positive probability that the government will legislate when only one company pollutes and this may be excessively punitive.

When the economy worsens companies reduce their belief about the likelihood for legislation. The first order stochastic dominance ordering on the family of distributions \( F(\psi|\theta) \) implies that \( \frac{\partial \Psi^{**}}{\partial \theta} > 0 \), that is, as the economy worsens companies believe that it is less likely that the government will legislate. I use this inequality to derive a number of comparative statics.

**Proposition 2.2.2** As the economy improves (\( \theta \uparrow \)) the likelihood that the government will legislate increases and the probability that a company pollutes decreases.

This is shown in the following where the effect of an increase in \( \theta \) on \( \rho^* \) is

\[
\frac{\partial \rho^*}{\partial \Psi^{**}} \cdot \frac{\partial \Psi^{**}}{\partial \theta} = -\left(\frac{\pi_p - \pi_0}{\Psi^{**}c}\right)\frac{\partial \Psi^{**}}{\partial \theta} < 0.
\]

Since each term on the right hand side of equation (2.11) is greater than 0 and multiplied by -1, therefore \( \frac{\partial \rho^*}{\partial \Psi^{**}} \cdot \frac{\partial \Psi^{**}}{\partial \theta} < 0 \). That is, an increase in \( \theta \) has a negative effect on \( \rho \). This result suggests that a credible legislative threat leads companies to not pollute since the expected cost of polluting due to legislation outweighs the benefit.

Although not the focus of my empirical strategy, additional comparative statics can be calculated. An increase in \( c \) increases the expected cost of polluting and so decreases the probability that a company will pollute:

\[
\frac{\partial \rho^*}{\partial c} = \frac{-(\pi_p - \pi_0)\Psi^{**}}{(\Psi^{**}c)^2} < 0.
\]

Conversely, an increase in the difference between \( \pi_p \) and \( \pi_0 \) increases the gain in payoff from polluting,
\[
\frac{\partial \rho^*}{\partial (\pi_p - \pi_0)} = \frac{\Psi^{**}c}{(\Psi^{**}c)^2} = \frac{1}{\Psi^{**}c} > 0,
\] (2.13)

and so increases the probability that a company will pollute.
Chapter 3

The Limitations of Overcompliance in an Uncertain Legislative Environment

3.1 Methodology

To better understand investors' reactions to companies that voluntarily overcomply in an uncertain legislative environment, I estimate the signaling model from subsection 2.1. Voluntary overcompliance in this case is represented by disclosing carbon emissions. Disclosure and nondisclosure (or withholding) are the two signals that a company must choose between when surveyed by the Carbon Disclosure Project (CDP).

3.1.1 Data

All daily price and returns data are sourced from the Canadian Financial Markets Research Centre (CFMRC) Database on Canadian common stocks from the beginning of 2005 to the end of 2006. Deleted from the sample were companies that did not have data for the full two-year period (523 trading days), companies with more than 100
trading days of returns data missing, and companies with 7 trading days of returns data in a row missing. I refer to this sample as the ‘Full’ sample and it includes 877 companies, as well as the CFMRC value-weighted index return. Data is unavailable on companies that went bankrupt, or were acquired. Other company-level information on the sample companies was retrieved from the Carbon Disclosure Project (CDP) website, the Canadian Greenhouse Gas Reporting Website, COMPUSTAT, Jantzi Research\(^1\) and Factiva. All variables are considered to be in the investor’s prior information set, where financial variables are calculated as of fiscal year 2005.

Survey response data was obtained from the Carbon Disclosure Project (CDP). In 2006, the largest (by market capitalization) 280 Canadian companies listed on the Toronto Stock Exchange (TSX) were surveyed by the CDP. Known as the CDP4, February 2006 was the first time that the CDP survey was sent to many Canadian companies requesting voluntary disclosure of their annual carbon emission levels. Participation in the survey was voluntary and the CDP released the information to the public in September 2006. The survey asked for both quantifiable information (yearly emissions) and unquantifiable information on the climate change risk of the company. In this study, the Canadian sample of the CDP4 climate change database is used. For the remainder of this dissertation, CDP4 refers to just the Canadian sample of the CDP’s 2006 survey. Other factors that affect companies’ decision to disclose emissions are described in the following paragraphs, where COMPUSTAT labels are in parentheses.

Companies that have disclosed emissions in other forums are more likely to disclose to the CDP. Information on whether companies reported greenhouse gas emissions to the government was obtained from the Canadian Greenhouse Gas Reporting Website. Only about 16% of Canadian companies surveyed by the CDP4 had facilities that also disclosed (2005) emissions information to the government, and only 44% of companies that disclosed to the CDP4 also disclosed to the government. In my study, I focus on

\(^1\)Jantzi Research is now a part of Sustainalytics.
voluntary disclosure as a signal of company type - that the act of voluntary disclosure itself is informative rather than the information disclosed, which is noisy. Empirically I find that the disclosed emission levels are not informative. The fact that some companies owned facilities that were required to disclose emissions information is relevant however in the sense that voluntary disclosure is likely to be less costly for companies who already make disclosures. That is, there could be economies of scale with respect to information production costs (Clarkson et al. (2008)). The CDP also requests disclosure of emissions from indirect sources, such as from purchased electricity.

There could be several costs associated with the voluntary disclosure of carbon emissions. For example, larger companies are typically under more scrutiny from stakeholders and may be subject to more institutional activism. I calculate company size as the natural logarithm of the total asset value \((at)\) reported in 2005. Companies with a high proportion of CDP signatory ownership may be more likely to disclose so as to not alienate those large investors. The variable representing companies that are more likely to feel pressure to disclose is the proportion of company ownership that is attributable to CDP signatories, as calculated by the CDP. I also include a binary variable indicating companies that own facilities which reported carbon emissions to the government in 2005. Companies that have information readily available to disclose should have a lower cost of disclosure. Other observables often used when modeling disclosure that I include are book-to-market value (the ratio of the book value \((ceq)\) of the stock to the market value of the stock), and industry (based on SIC codes). Industry serves as a proxy for costs of disclosure, since pollution propensity and related monitoring by stakeholders varies by industry (See Clarkson et al. (2008)). In addition, industry can be used to identify companies with a high tendency for pollution. I include a binary variable equal to one if the company is in the manufacturing, mining, transportation or utilities sector.

One possible benefit from disclosure is that it may lower the company’s cost of capital since disclosure can reduce information asymmetry (Healy and Palepu (2001)). That
is, companies with more information asymmetry may benefit more from voluntary disclosure. One measure of information asymmetry is Tobin’s Q, based on the argument that companies with greater unbooked intangibles and a positive net present value investment opportunity set enjoy a larger Tobin’s Q (Clarkson et al. (2008)). A Tobin’s Q value greater than 1 implies that the market value is greater than the value of the company’s recorded assets, and is calculated as the market value of the company divided by the book value. I construct this measure using the closing price of the stock at the end of 2005 and multiplying it by the number of common shares outstanding (\(cs ho\)). This value is added to the preferred stock (\(ps tk\)) and short- (\(dlc\)) and long-term debt (\(dl tt\)) to calculate the market value of the company. The book value of the company is calculated as the sum of property, plant and equipment (\(pp en t\)), inventories (\(inv t\)), cash and short term investments (\(ch e\)) and receivables (\(re c t\)). Another measure of information asymmetry is stock price volatility, and I measure this using the 2005 standard deviation of monthly stock returns and daily stock returns, although it is difficult to disentangle the effect of information asymmetry from risk in general. In addition, companies that raise capital in debt and equity markets have a higher propensity for voluntary disclosure to lower their cost of capital. The financing available to the company is the amount of debt or equity capital raised by the company in the fiscal year, and is the sale of common stock and preferred shares minus the purchase of common stock and preferred shares (\(ss tk - pr st kc\)) plus long term debt issuance (\(dl t is\)) minus the long term debt reduction (\(dl tr\)).

It has been found that companies with a higher pollution propensity tend to make more disclosures than other companies (See for example, Bewley and Li (2000)). Companies with newer equipment may have less carbon emissions than average and thus may be more willing to disclose carbon emissions (Clarkson et al. (2008)). I calculate a few variables indicative of the type of technology employed by the company. Asset newness is measured as a ratio of net properties, plant and equipment (\(pp en t\)) divided by the
Chapter 3. The Limitations of Overcompliance

gross properties, plant and equipment \((ppe\text{gt})\) at the end of fiscal year. Capital intensity is measured as a ratio of capital spending \((capx)\) divided by total sales revenue \((sale)\) at the end of the fiscal year. Environmental performance is measured using a score calculated and published by Jantzi Research (now Sustainalytics), who develops a variety of scores relating to Corporate Social Responsibility (CSR) for companies. Information for score calculation is compiled from public documents, government and NGO sources, media reports and correspondence with key stakeholders. Each company also receives a questionnaire about its CSR practices. For the environmental performance score, Jantzi translates the combined scores in a variety environmental areas in one final score out of ten. Although the details of best practices vary by industry and the scoring criteria are weighted differently, the grades are assigned such that comparison across industries is possible.

The variables described are calculated for the Full sample. The selection of companies that the CDP4 surveyed in 2006 can be extracted from the Full sample. Further, this CDP4 sample can be separated into two subsamples: those companies that disclosed emissions and those companies that did not. A summary of each sample is provided in Table 7.7. Table 7.7 indicates that there are several differences between the CDP4 sample and the larger Full sample, which includes the CDP4 sample. Since the CDP4 surveyed companies that were largest by market capitalization, it is clear that the CDP4 sample is not representative of the full sample, although there are similarities. The CDP4 sample is fairly representative of the Full sample in terms of industry composition, asset newness, and capital intensity. As the CDP4 sample contains only the largest (as of 2006) companies, 2005 average total sales are higher and their 2005 stock prices are less volatile on average.

There are several differences between the subsample of companies that disclosed emissions to the CDP4 and the companies that were surveyed by the CDP4 but did not disclose. Companies that disclosed were, on average, significantly larger in terms of
market value and total sales, but smaller on average in terms of capital raised by the company. Interestingly, there was no significant difference in terms of the percentage of market capitalization owned by CDP signatories. This difference implies that companies that disclosed may not have been heavily influenced by CDP signatory ownership of their stock. Not surprisingly, companies that disclosed had a higher environmental performance score on average. Companies with better environmental performance are probably more likely to track emissions data and volunteer environmental information.

Finally, Factiva was used to determine which companies had any confounding events during the time frame studied.

3.1.2 Estimation of the Propensity to Disclose

In order to test if investors believe that the likelihood of legislation is high and thus that the stock price is monotonic in the signal, I follow the empirical strategy of Acharya (1988). A manager’s decision rules can be represented empirically using a probit model. The expected difference in payoffs between disclosing and not disclosing is unobservable and is assumed to be a normal random variable, denoted by $y$. Let $y = u + \xi$, where $u$ is investors’ prior expectation of $y$ and $\xi$ is private information represented by a normal random variable with zero mean, given investors’ prior information. Both sides of the inequalities are divided by the standard deviation of $\xi$ such that the resulting inequalities have unit variance.

Using $y = u + \xi$, the manager’s decision rules are: choose d if and only if $\xi \geq -u$; choose n if and only if $\xi < -u$. These decision rules can be represented with a probit model. I assume that investors’ expectations about $y_i$ are homogenous and linear in their information, and that there exists a vector of variables $z_i$ in the investors’ prior information set that are relevant to a manager’s decision rules. This vector proxies for investors’ expectation prior to manager signaling. As such, investors’ expectations
about \( y_i \) can be characterized by

\[
    u_i = E[y_i | z_i] = \vartheta' z_i,
\]

(3.1)

where \( \vartheta \) is a conforming vector of probit coefficients. A manager’s decision rules can now be represented as:

- choose \( d \) if and only if \( \vartheta' z_i + \xi_i > 0 \)
- choose \( n \) if and only if \( \vartheta' z_i + \xi_i \leq 0 \)

where \( \xi \) is private information and the probit error term, which is assumed to follow a standard normal distribution. The variables in \( z_i \) are ex-ante (2005) variables and are described in the previous section. Estimation of this probit model represents the first stage in a two-stage procedure used in this study, and can be represented as

\[
    D^* = \hat{\vartheta}' z_i + \xi_i,
\]

(3.2)

where \( D^* = 1 \) when the manager discloses emissions information and zero otherwise.

### 3.1.3 Estimation of the Average Daily Abnormal Returns

Recall that \( P(s, \varsigma) \) is the stock price of a company after all companies have issued a signal. The expected return to the company’s stock after the signal has been issued can be represented as:

\[
    E \left[ \frac{P(s, \varsigma) - P_0}{P_0} \Big| s, \varsigma \right] \equiv E[R_{s\varsigma} \Big| s, \varsigma],
\]

(3.3)

where \( R_{s\varsigma} \) is the rate of return on the stock of the company observed conditional on the signal \( s \) and the composition of signals in the market \( \varsigma \), such that a test of the prediction \( P_t(d, \varsigma \geq \varsigma^*) > P_t(n, \varsigma \geq \varsigma^*) \) is also a test of

\[
    E[R_{d\varsigma} \Big| d, \varsigma \geq \varsigma^*] > E[R_{n\varsigma} \Big| n, \varsigma \geq \varsigma^*].
\]

(3.4)
This prediction of the signaling model can be further reduced. The rate of return of a stock can be written as \( R_s = \mu + \epsilon_s \), where \( \mu \), the ‘normal return’, is determined by market-wide movements in stock returns and is unrelated to the signal, and \( \epsilon_s \) is possibly related to the signal (and the composition of signals in the market). It is assumed that \( \epsilon_s \) is a stationary random variable that is zero in expectation. As such, the relation in (3.4) can be written as

\[
E[\epsilon_s | d, \varsigma \geq \varsigma^*] > E[\epsilon_n | n, \varsigma \geq \varsigma^*].
\] (3.5)

An explicit expression for \( E[\epsilon_s | s, \varsigma] \) is necessary for estimation. Note that \( E[\epsilon_s | s, \varsigma] \) is the conditional announcement effect on the stock price associated with signal \( s \) and ratio \( \varsigma \). Recall that \( \xi \) is companies’ private information. Since \( \epsilon_s \) and \( \xi \) are stationary random variables, by the projection theorem and the fact that \( \xi \) has unit variance it is true that \( \epsilon_s = \text{cov}(\epsilon_s, \xi)\xi + \zeta \). Letting \( \pi_s = \text{cov}(\epsilon_s, \xi) \), then \( \epsilon_s = \pi_s \xi + \zeta \). Therefore, an explicit expression for \( E[\epsilon_s | s, \varsigma] \) is

\[
E[\epsilon_s | d, \varsigma] = \pi_{ds} \frac{\varphi(-u)}{1 - \Theta(-u)} = \pi_{ds} \frac{\varphi(u)}{\Theta(u)} = \pi_{ds} \lambda_{ds},
\] (3.6)

\[
E[\epsilon_n | n, \varsigma] = \pi_{ns} \frac{-\varphi(-u)}{\Theta(-u)} = \pi_{ns} \frac{-\varphi(u)}{1 - \Theta(u)} = \pi_{ns} \lambda_{ns},
\] (3.7)

where the standard normal probability density is \( \varphi \), and \( \Theta \) is the standard normal cumulative distribution function, and \( \lambda \) is the inverse mills ratio. The inverse mills ratio is the ratio of the probability density function over the cumulative density function, and is also known as the selection hazard. To guarantee that \( E[\epsilon] = 0 \), it is necessary that \( \pi_{ds} = \pi_{ns} = \pi \). Hence, it can be written that

\[
E[\epsilon_s | s, \varsigma] = \pi \lambda_s, \quad (3.8)
\]
and this represents the conditional announcement effect associated with signal $s$. Hence, a test of the prediction of the signaling model is just a test of $\pi \lambda_{d\varsigma} > \pi \lambda_{n\varsigma}$. If $\varsigma \geq \varsigma^*$, then $\lambda_{d\varsigma} > 0$ and $\lambda_{n\varsigma} < 0$, and so I only need to test that $\pi > 0$ in the following model

$$ R = \mu + \pi [\lambda_{d\varsigma} I_d] + \pi [\lambda_{n\varsigma} I_n] + \nu, \quad (3.9) $$

where $I_d$ is an indicator variable equal to one if the manager disclosed and $I_n$ is an indicator variable equal to one if the manager did not disclose. This model is a simple representation of the second stage regression. If $\pi > 0$, then companies are rewarded for disclosing and the implication is that investors believe future legislation to be likely. If $\pi < 0$, then companies are rewarded for not disclosing and the implication is that investors believe future legislation to be unlikely.

Before estimating the second stage regression, estimates of $\lambda_{d\varsigma}$ and $\lambda_{n\varsigma}$ are necessary. Estimates of $\lambda_{d\varsigma}$ and $\lambda_{n\varsigma}$ are calculated from the first stage regression, as can be seen from equations (3.2), (3.6) and (3.7). These estimates of $\lambda_{d\varsigma}$ and $\lambda_{n\varsigma}$ are then used in the second stage GLS regression:

$$ R_{it} = \mu_{it} + \pi [\hat{\lambda}_{d\varsigma i} I_{di}] + \pi [\hat{\lambda}_{n\varsigma i} I_{ni}] + \nu_{it}, \quad (3.10) $$

which is a (panel data) variation on Heckman’s two-step method for cross-sectional models. This variation is important because Heckman’s method does not incorporate any possible cross-sectional covariance of $\nu_{it}$, nor does it guarantee that $E(\epsilon_{it}) = 0$ (Acharya (1988)). I use (a variation on) Heckman’s two-step method to correct for the endogeneity bias inherent in this data since companies choose how to respond to the CDP survey. I do not include other regressors in this model since the signal effects should not be related.

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3The estimation in (3.9) could also be completed without the selection hazard variables - just the dummy variables. This method however does not take advantage of information in investors’ prior information set regarding the likelihood of company disclosure and the effect this has on abnormal returns.
to ex-ante variables under the efficient market hypothesis.

### 3.1.4 Estimation of the Daily ‘Normal’ Returns

I assume that stock returns maintain a constant linear relationship with the market return, as is typical of event studies. For short-horizon event studies using daily data, variables such as market capitalization and price-to-book value ratios are typically not significant (Kothari and Warner (2007)). Using the Full sample of companies and their associated 2005 returns data, the linear relationship between each stock return and the market return is estimated. This method is known as the market model and is commonly used in the literature. For each stock $i$,

$$R_{it} = \alpha_i + \beta_i^m Y_t + e_{it},$$

(3.11)

is estimated. The rate of return (henceforth just the return) for stock $i$ at time $t$ is $R_{it}$, and $Y_t$ is the rate of return of the market, represented here by the CFMRC value-weighted index. Once estimates of $\alpha$ and $\beta^m$ are obtained, then the normal return (represented by $\mu_{it}$ in equation (3.10)) for each stock during the event window is estimated as follows

$$E[R_{it} | Y_t] = \alpha_i + \beta_i^m Y_t,$$

(3.12)

and can be thought of as the return that would have occurred for the stock in absence of the event (signaling). As mentioned, the estimation window in this model consists of all trading days in 2005.

One research design issue here is to determine what the appropriate event window should be. That is, to determine over what time frame should the stock returns of companies be examined in order to analyze the market impact of their CDP survey response. Companies could respond to the survey at any time from early February 2006
until just after the May 31st, 2006 deadline. Importantly, the institutional investor signatories to the CDP had access to the response data before the public release in September 2006. Signatories would have had access to response data shortly after it was submitted for companies that responded electronically, and somewhat later if the manager responded by hard copy forms. Although the exact dates of submission by each company were not recorded, most companies had responded by the May 31, 2006 deadline, with the remaining companies responding in early June. Given that a shorter event window is preferable to minimize the possibility of confounding events, May 30 2006 to June 12 2006, a total of 10 trading days, is used as the main event window.

Based on equation (3.12) and an event window length of 10 days, the second stage regression in (3.10) can be rewritten as

\[ R_{it} = E[R_{it} | Y_t] + \pi \hat{\lambda}_{di} I_{di} + \pi \hat{\lambda}_{mi} I_{mi} + \pi_{gi} I_{gi} + \nu_{it}, \]  

(3.13)

where \( t \) represents the 10 trading days and \( I_{gi} \) is an indicator variable equal to one if the company was not in the CDP4 sample. As in Acharya (1988), a random selection of thirty stocks from the Full sample (that are not in the CDP4 sample) are used in the regression. Several random selections are made to ensure that the results do not vary substantially between random samples.

For clarity, in equation (3.13) I have separated the inverse mills ratios for companies that disclosed and companies that withheld into two terms using dummy variables. Note however, that the coefficient on these two terms is the same (\( \pi \)). I estimate \( \pi \) by collecting these two variables into one variable representing the inverse mills ratio.

It is also important to exclude companies surveyed by the CDP4 for which there are known confounding events during the event window time frame of May 29 to June 12, 2006. Using the news database Factiva, I exclude companies that had earnings announcements.

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4 The Conference Board of Canada authored the Canadian CDP4 report. Discussions with employees at the Conference Board of Canada provided this information.
or mergers and acquisitions news published by The Globe and Mail during the event window time frame. There were only thirteen companies that were excluded and as such the results are very similar when these companies are included compared to when they are excluded.

3.2 Results and Discussion

3.2.1 Estimation Results

In order to test whether companies’ stock prices increase after signaling (i.e. \( \pi > 0 \)), a two-stage estimation procedure is employed. The first stage in this procedure is to estimate the propensity to disclose using a probit model. There are several ex-ante (2005) variables that could have affected a company’s carbon emissions disclosure decision in 2006. A correlation matrix can be found in Table 7.2. It is not the focus of this dissertation to determine the best model of disclosure, however it is important to ensure that several relevant variables are included in the model. I estimate the propensity to disclose first using all variables and then using select variables resulting in four estimations in total.

Estimation of the model of the propensity to disclose (equation 3.2) can be seen in Table 7.3. Many of the coefficients are found to be insignificant, most interestingly the proportion of market capitalization owned by CDP signatories.\(^5\) This result suggests that on average companies are not pressured by large investors into disclosing. Kim and Lyon (2008) stated that the possibility of companies not being pressured by large investors into CDP participation would be hard to argue. In their research they found a positive relationship between participation in the survey and CDP signatory ownership, however

\(^5\)Of the companies included in the sample for this regression, four had less than 1 percent of market capitalization owned by CDP signatories. On average, CDP signatories owned 13 percent of the market capitalization of the companies surveyed by the CDP4.
their definition of participation included qualitative statements without disclosure of emissions information. I agree that companies could be easily pressured into giving qualitative statements, as this option is of low cost and low commitment. In addition, if a company did not track emissions in the previous year, then the influence of large shareholders is limited to the disclosure of indirect emissions. Combining my results with that of Kim and Lyon (2008) supports socio-political theories of disclosure such as legitimacy theory. That is, companies whose legitimacy is questioned by institutional investors may make soft (inexpensive) claims to be committed to the environment in order to improve their environmental reputation and increase legitimacy. Note that my theoretical framework implicitly assumes that companies are not influenced to disclose.

It can also be seen that larger companies, companies with a higher environmental performance score, companies in a high pollution-propensity industry and companies that own facilities that have reported GHG emissions to the government are more likely to voluntarily disclose carbon emissions. These results coincide with previous research (See Clarkson et al. (2008)). Larger companies may be subject to more reputational risk, and companies with higher environmental performance scores and companies in high pollution-propensity industries are more likely willing to disclose to send a positive signal to investors. Clearly, any company that has already disclosed a large portion of their emissions to the government may be more inclined to disclose to the CDP.

Since environmental performance scores are not available for all companies in the CDP4 sample, including the environmental performance score reduces the sample size greatly. In model 4 of Table 7.3 the environmental performance score is removed, and the sample size increases from 145 in model 3 to 207 in model 4. All four models are used to create estimates of $\lambda_{sci}$, which are then utilized in calculating the estimates of $\pi$ and $\pi_g$ in the second stage regression (3.13). The average values of $\lambda_{sci}$ calculated by each model do not vary substantially, as can be seen in the bottom rows of Table 7.3.

Estimation of the model of the propensity to disclose that included a measure of
profitability was excluded from tabulated results. The coefficient on profitability was
insignificant and did not much affect the results of the estimation. One explanation as to
why a measure of profitability is not significant using this data sample is that there could
have been only a few managers who believed that future climate change action was likely.
A manager who does not consider legal action on carbon emissions as a risk would not
probably not consider tracking emissions regardless of the company’s profitability. Using
a different sample however, where there are many companies with managers who believe
that legislation is likely, could produce results from an estimation of the propensity to
disclose where the measure of profitability is positive and significant.

It is also important to consider the possibility that management of some companies
did not disclose direct carbon emissions simply because they did not have the information
available. The CDP survey was sent to companies in February 2006 asking about 2005
emissions. Management could have anticipated receiving the survey however, since the
CDP was initiated in 2001. Also, if management had not been tracking direct emissions,
they could still have chosen to disclose indirect emissions, such as those from purchased
electricity. In the CDP4 however, there were no companies that disclosed indirect emis-
sions only. Management was given several months to respond to the survey (February to
the end of May 2006), but it is possible this time frame was not long enough for some
companies to respond.

Table 7.4 shows results from the second stage regression, using the estimates of $\lambda_{s\varsigma_i}$
shown in Table 7.3. Table 7.4 shows results using the ten trading days event window
of May 30 to June 12, 2006 for companies in all industries. Since the estimate of $\pi$ is less
than zero in each case, the implication is that the ratio of the number of companies that
disclosed to the total number of companies ($\varsigma$) is less than the critical value ($\varsigma^*$). The
value of $\pi$ implies that companies that disclose lose an average of 12 to 13 basis points
a day in the days surrounding the CDP deadline, whereas companies that withheld
this information gained an average of 3 to 5 basis points a day. For companies that
disclose, this translates to a loss in market value of about $11 million a day on average, and a gain of $3 million a day on average for companies that do not disclose. These amounts are found by multiplying the abnormal return by the market value of the stock on May 29th, 2006, and averaging over all stocks.

It is possible that by examining all sectors together, the analysis ignores important differences between companies with high pollution propensity that would be most affected by climate change legislation and the companies in low pollution propensity sectors that disclose possibly for public relations reasons. Table 7.5 examines companies in the manufacturing, mining, transportation and utilities industries only. Results for these carbon-intensive industries are similar to results in Table 7.4 for all companies. Again, \( \pi < 0 \), so the implication again is that the ratio of the number of companies that disclosed to the total number of companies is less than the critical value. I find that companies which disclose also lose about $12 million a day on average, and companies that did not disclose gain about $3 million a day on average.

Although the effects found are small, they are significant and indicate that investors do not react to disclosure the way managers might have thought. It is also important to note the coefficient on the variable that indicates if the company is in the CDP4, \( I_{gi} \). This variable should not be significant because companies not in the CDP4 survey should not have any abnormal return during the event window, assuming that the normal return is estimated correctly. In all the cases shown in Table 7.4 the coefficient on non-CDP4 companies is not significant. In all cases in shown in Table 7.5 the coefficient on non-CDP4 companies is significant. Overall, the results suggest that investors believe that the likelihood of future climate change legislation is low. However, a manager that believes there will be new legal action on carbon emissions is probably unconcerned by this immediate small effect. If the manager proves to be right at some point, their previous voluntary disclosure could highlight their company to investors as a good investment option and their stock price would increase.
3.2.2 Robustness Checks

For event studies where the public release of TRI data is the event, the abnormal returns calculated are often regressed (cross-sectionally) on a variety of company characteristics, with the variable of interest being the ratio of toxics emissions to total sales. In this study of carbon emissions disclosure however, it is possible that the emission levels disclosed were considered uninformative by investors since this data is noisy. There was no required reporting standard for emissions and not all emissions reported had been audited. To test the argument that the emission levels disclosed were generally uninformative to investors, the abnormal returns from disclosure were regressed on the ratio of emissions to sales for 2005 and the ratio was found to have an insignificant impact. Abnormal returns were also regressed on a variable ranking the companies on emissions to sales within the mining, manufacturing, transportation and utilities industries and outside, and other variations on this method were attempted with the same result. These results support the notion that the level of carbon emissions disclosed are less informative to stock valuation than the act of disclosure itself.

I also examine variations on the research design to test the robustness of the results. I adjust the length and time frame of the event window, and I also use other methods of estimating ‘normal’ returns and compare the results to those discussed previously (shown in Table 7.4).

In Table 7.4 the event window is 10 trading days in length from May 30 to June 12, 2006. I conduct the same analysis with an event window starting May 30 and lasting 2 and 5 trading days in length; starting May 29 and lasting 5 trading days; and starting February 1 and lasting 106 trading days (six months). The six-month event window is not ideal since it is quite long and there may be many confounding events during that time. The rationale for the six-month event window is that companies could respond to the survey immediately after they received the survey questionnaire (either electronically or by hard-copy form), and CDP signatories would have had access to this information
soon after. Although a record of the timing of each submission was not maintained, most companies responded to the survey by May 31 2006. Similar results were found for each event window length, however in some cases the results were not significant.

In Table 7.4 the market model is employed to estimate normal returns for stocks in the sample as this was recommended by the literature. Other methods of estimating normal returns include average returns, the capital asset pricing model (CAPM) and the Fama-French three factor model. The CAPM can be represented as

\[ R_{it} = R_{ft} + \beta_1(Y_t - R_{ft}) + \alpha_t, \]  

(3.14)

where \( R_{ft} \) is the risk-free rate of return and \( Y_t \) is the rate of return on the CFMRC value-weighted index. The Fama-French three factor model is the same as the CAPM model but with two more factors such that

\[ R_{it} = R_{ft} + \beta_1(Y_t - R_{ft}) + \beta_2 \cdot SMB_t + \beta_3 \cdot HML_t + \alpha_t, \]  

(3.15)

where \( SMB_t \) is a measure of the excess returns of small-cap stocks over large-cap stocks and \( HML_t \) is a measure of the excess returns of value stocks over growth stocks. Both of these methods are used to estimate ‘normal’ returns \((\mu_{it})\) for the second-stage regression. The results from doing so are similar to results from the original analysis completed using the market model, and so have not been included in the tabulated regressions. For the Fama-French three factor model, the factors were downloaded from HEC Montreal’s website for CGA Professorship in Strategic Financial Information. Using this model, similar results were found to that in Table 7.4 but were insignificant in this case. Using a longer event window - six months from February 1 to June 30, 2006 - significant results were found in one case and these results can be seen in Table 7.6. Using the Fama-

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6The Conference Board of Canada authored the Canadian CDP4 report. Discussions with employees at the Conference Board of Canada provided this information.
French three factor model to estimate normal returns is common in long-horizon event studies (Kothari and Warner (2007)).

Other methods can be employed to deal with endogeneity. I also employed propensity score matching, though I chose not to tabulate these results since I did not believe my sample size to be sufficiently large so as to be confident that the difference in group averages would accurately reflect the effect of the survey responses.
Chapter 4

The Credibility of Legislative Threat to Encourage Overcompliance

4.1 Methodology

In section 2.2, I model choice of carbon emissions level as a function of a company’s belief about the credibility of legislative threat. To better understand legislative threat, I estimate the effect it has on company value for carbon-intensive companies. The financial market response to legislative threat represents a measure of this credibility.

4.1.1 Legislative Threat during an Economic Decline

In this chapter, I examine the threat of an emissions trading scheme. When Barack Obama became president-elect of the U.S. in November 2008 a central component of his campaign was to reduce carbon emissions. Although it was reported in July 2010 that the U.S. Senate would not consider climate change legislation before the end of the legislative term, it is arguable that the threat was present until that time. I choose this event as it represents a significant and broad-based legislative threat, and also because it occurred during a time of recession allowing for examination of how the unanticipated
depth of the recession impacted the credibility of the threat.

### 4.1.2 Sample Selection and Calculation of Variables

The sample consists of a balanced panel of quarterly financial and accounting data on U.S. publicly traded companies from the fourth quarter of 2006 to the third quarter of 2010 (two years before the threat, and two years after), sourced from COMPUSTAT. Certain states were excluded from the sample if they had carbon taxes in place or a regional emissions trading scheme. Observations dropped from the sample include duplicate observations, observations where the financial and accounting data was not calculated at quarter-end, and observations with large values for Tobin’s Q (greater than 3) as well as observations where Tobin’s Q could not be calculated. Tobin’s Q is a commonly used measure of company value (Hirsch and Seaks (1993)), and it is the dependent variable in my study. **Tobin’s Q** is calculated as in Konar and Cohen (2001):

$$Q = \frac{\text{Market Value (Common Stock + Debt + Preferred Stock)}}{\text{Book Value (Plant + Equipment + Inventory + Short Term Assets)}} \quad (4.1)$$

Variables used in the methodology are calculated as described in the following, where quarterly COMPUSTAT labels are in parentheses. For calculation of Tobin’s Q, the market value of common stock is calculated as the quarter-end share price ($prccq$) multiplied by the common shares outstanding ($cshpry$). This value is added to the preferred stock ($pstkq$) and short- ($dlcq$) and long-term debt ($dlttq$) to calculate the market value of the company. The book value of the company is calculated as the sum of property, plant and equipment ($ppentq$), inventories ($invtq$), cash and short term investments ($cheq$) and receivables ($rectq$). This calculation of book value is at cost, as per the financial statements.

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1. Excluded from the sample were companies in California, Colorado, and power plants in the RGGI.
2. Inclusion of large values of Tobin’s Q did not significantly affect the results.
3. See Konar and Cohen (2001) and Hirsch and Seaks (1993) for discussions of measurement issues regarding estimation of Tobin’s Q.
of the company. I chose not to inflate the book value of property, plant and equipment using a producer price index since having older equipment (lower replacement cost) can represent a greater option value for the company. That is, since these companies have not recently purchased new equipment they are more likely in a better position to change their production process in response to threat of legal action on carbon emissions.

Certain variables are important determinants of company value and so are employed as controls. **Company size** is proxied by the natural log of the total assets ($atq$) of the company. **Leverage** is calculated as the sum of total long-term debt ($dlttq$) and debt in current liabilities ($dlcq$) scaled by total assets. **Return on Assets** is calculated as operating income before depreciation ($oibdpq$) dividing by total assets. Since it is possible that operating income may also be impacted by regulatory threat if the company tries to reduce emissions or purchase carbon credits, return on assets is proxied using the two-year lag of return on assets. **Sales growth percentage** is total sales ($saleq$) for the quarter divided by total sales from the same quarter in the previous year, and then minus 1. **Sales turnover ratio** is total sales ($saleq$) for the quarter divided by total assets ($atq$). Also included is a dummy variable equal to one if the company is **incorporated in Delaware** ($incorp$), as Delaware corporate law has been found to improve firm value (Daines (2001)). Summary statistics for these variables over the full time frame of the sample can be found in Table 7.7. Correlations between these variables can be found in Table 7.8.

### 4.1.3 Estimation

I employ differences-in-differences estimation in order to estimate the effect of recession on the credibility of legislative threat. There are two groups based on industry: (1) carbon-intensive companies and (2) non carbon-intensive companies. I include the full sample (16 quarters), where the threat of an emissions trading scheme occurs in the fourth quarter of 2008 when Obama became president-elect of the U.S. The implicit
assumption here is that Obama’s election, and thus the emissions trading scheme threat, were unanticipated by financial markets as of the end of the third quarter of 2008.

Legislative threat affects the outlook for future profitability of a company, and so it also affects the financial market value of the company. The size of the effect of legislative threat on company value can provide useful information about general sentiment regarding the credibility of the threat. The effect of legislative threat on company value can be thought of as equal to the company’s cost of legislation multiplied by a discount factor multiplied by the probability of legislation. The probability of legislation is a measure of the credibility of the threat of legislation, and I test if the unanticipated depth of the recession reduces this component of the threat effect. I assume that the state of the economy has no impact on the cost of legislation to a company - this cost can be thought of as a function of the technology of the company.

The measure of company valuation that I use in this study is Tobin’s Q. Theory does not suggest a functional form for Tobin’s Q, however a log-linear specification has been found to be preferable to a linear form (Hirsch and Seaks (1993)). In the following specification, company is denoted by subscript $i$, state by subscript $s$, and time by subscript $t$. The equation to be estimated is shown below, where time and state effects are modeled semi-parametrically, with a separate dummy variable for each quarter and state:

$$ q_{ist} = \beta_0 + \beta_1 P_t + \beta_2 T_i + \beta_3 (T_i \cdot P_t) + \beta_4 (\theta_t \cdot T_i \cdot P_t) + \beta_5 \theta_t + \beta_6 (T_i \cdot P_t \cdot L_t) + \sum_{i=1}^{N} \sum_{t=1}^{T} \theta_{it} X_{it} + \sum_{s=1}^{S} \mu_s D_s + \sum_{t=1}^{T} \mu_t D_t + \epsilon_{ist}, \quad (4.2) $$

where $q_{ist}$ is the measure of company market value (natural log of Tobin’s Q), $P_t$ is a dummy that is equal to 1 if the quarter is within two years following a threat event, $T_i$ is dummy variable equal to one if the company is in the carbon-intensive group (the treated group), $\theta_t$ is a measure of the current economic situation, $L_t$ is equal to the number of quarters since Obama became president, and $X_{it}$ is a vector of variables that
affect company value described in subsection (4.1.2). State and quarter dummy variables are represented by $D_s$ and $D_t$ respectively.

To represent the current economic situation ($\theta_t$), the measure I use is the cumulative difference from peak real gross domestic product (GDP). This measure represents the deviation from trend GDP: it starts at zero when GDP is at its peak level, and decreases to minimum when GDP reaches the peak level again, and returns to zero when GDP reaches a level more consistent with the pre-recession trend. This measure then increases as GDP continues on that trend. A graph of this variable can be seen in Figure 7.3. This measure is intended to better capture the unanticipated component of the recession. That is, by the end of 2008 investors probably anticipated/expected the recession, however the depth of the recession was largely unanticipated.\footnote{Other measures used were (lagged and not lagged) quarter-over-quarter GDP growth as well as a level measure of GDP. The issue with using these measures is that as the economy is recovering, the measures are increasing and do not reflect the deviation from the pre-recession trend GDP.}

The coefficient of interest in equation (4.2) is $\beta_4$, as this measures the total (discontinuous) effect of the economic climate on the credibility (i.e. probability) of the legislative threat. The total effect of legislative threat on firm value would be measured as

$$
\beta_3 + \beta_4(\theta_t) + \beta_6(L_t).
$$

Equation (4.2) shows the main specification in linear form, and I estimate this model using ordinary least squares (OLS). Since company-level regressors are included in the differences-in-differences estimation, the standard errors need to be adjusted for group-level random effects. I cluster the standard errors by state, where state is as defined in COMPUSTAT. This approach, rather than clustering by state and quarter, is a widely-used method to deal with serial correlation (Duflo et al, 2004). In tabulated regressions I cluster the standard errors by state. Similar results were found when clustering standard errors by state and quarter. Another method to deal with random effects is to use
generalized least squares (GLS), and so I use this method as well and present the results for the main estimation.

4.1.4 Limitations

The specification in equation (4.2) permits estimation of how the unanticipated decline in the economic climate impacts the average treatment effect of legislative threat. An implicit assumption is that there is no interference between units. That is, I assume that outcomes of the untreated companies are not affected by the threat event.

One variable that is unobservable is the general expectation of investors about the type of environmental law that carbon emitting companies would face prior to Obama’s election. If rigid quotas were expected, then it is possible that trade-able permits would be viewed as an unambiguous improvement. In this case, describing an emissions trading scheme as a legislative threat is a misnomer.

This analysis is of an event study nature, and so it shares some of the issues that are common with event studies. It is implicitly assumed that Obama’s election was not priced in by financial markets prior to the beginning of October 2008, since I examine quarter-end Tobin’s Q values as my measure of company value. This assumption may not be completely accurate, however it is very likely that a higher probability of Obama’s election was not priced in until later in October.

Another consideration is that Obama’s election may have also had a negative effect on stock prices in general. The methodology used here however assumes that the difference between the treatment and control group is constant over time, which may still be a reasonable assumption even if all stock prices decreased. Similarly, the time frame of this analysis is unfortunate in that it includes a particularly volatile period for equity markets. It is important to consider that valuations during this time may have been driven largely by investor sentiment. Relative relationships between stock prices however, may have been less affected during this time.
Chapter 4. The Credibility of Legislative Threat

4.2 Results

4.2.1 Estimation Results

Tables 7.9 and 7.10 display the results from estimation of log-linear models of Tobin’s Q using OLS and GLS respectively. I also estimated a Nonlinear least squares specification that had similar results and so it is not shown. In each table there are four models. Model 1 does not include state or quarter fixed effects, model 2 includes state fixed effects, model 3 includes quarter fixed effects, and model 4 includes both state and quarter fixed effects. The coefficient estimates are similar across specifications and appear reasonable. The lagged return on assets (operating income/assets) variable seems to have the largest positive effect on company value. One difference is that sales/assets is insignificant in every model of the OLS specification, but is significant in every GLS specification. In both tables the inclusion of quarter dummies causes the cumulative difference from peak variable to be dropped from the regression, possibly due to over-specification.

The coefficients on \( \theta_t \cdot T_s \cdot P_t \) and \( T_s \cdot P_t \) are the focus of my study. In every case, the coefficients of interest are statistically significant. The quarters since threat variable, \( L_t \), is insignificant in many cases. This result implies that the reduction in credibility of the threat is not driven by the passage of time. The two variables \( \theta_t \) and \( L_t \) are negatively correlated however, so it is difficult to say with certainty.

I focus on the results of model 2 of Table 7.9 and ignore the quarters since threat variable, \( L_t \), as it is found to be insignificant. Log-linear regression models imply that underlying variables interact in a multiplicative way. All else being equal, for treated firms in the post-treatment period the average effect on the natural log of Tobin’s Q is equal to \(-0.259 + (-1.037)(\theta_t)\). In the first quarter after the event, the effect is equal to:

\[-0.259 + (-1.037) \cdot (\theta_{Q4,2008}) = -0.259 + (-1.037) \cdot (-0.05386) \approx -0.2\]

If the natural log of Tobin’s Q is decreased by 0.2 on average, then Tobin’s Q will be decreased by a factor of 0.82 \((\exp(-0.2) = 0.82)\). A decrease by a factor of 0.82 is
approximately equal to a 18% decrease in company value - a significant amount. In the fourth quarter of 2009 however, the effect is equal to:

\[-0.259 + (-1.037) \cdot (\theta_{Q4,2009}) = -0.259 + (-1.037) \cdot (-0.24702) \approx -0.003,\]
such that there is almost no legislative threat effect. In the third quarter of 2010:

\[-0.259 + (-1.037) \cdot (\theta_{Q3,2010}) = -0.259 + (-1.037) \cdot (-0.29485) \approx 0.046,\]
which implies that Tobin’s Q will be increased by a factor of 1.05 \(exp(0.046) \approx 1.05\) - or an increase of 5%.

I also estimate equation (4.2) where the control group consists of power plant companies in the Regional Greenhouse Gas Initiative States. These power plant companies have been part of an emissions trading scheme since late 2008. Results from this OLS estimation can be seen in Table 7.11 and they are similar to the results found in Tables 7.9 and 7.10. However, when RGGI power plants are the control group the initial decrease in the first quarter after the event is equal to

\[-0.610 + (-2.211) \cdot (\theta_{Q4,2008}) = -0.610 + (-2.211) \cdot (-0.05386) \approx -0.5\]
which implies that Tobin’s Q will be decreased by a factor of 0.61 - a large amount. This decrease may be overestimated since many investors are likely to have moved their money out of shares of companies in the treatment group and into shares of companies in the control group (RGGI power plants). Many investors may have wished to maintain a certain investment allocation in carbon-intensive companies like power plants, particularly since power plants are non-cyclical stocks and this event was during the beginning of a recession. This action by investors may violate the common trends assumption associated with differences-in-differences methodology.

### 4.2.2 Robustness Checks

An emissions trading scheme may provide a competitive advantage to some companies that can profitably sell pollution permits. Assuming that investors have knowledge of the carbon profile of companies, then there could exist some carbon-intensive companies
that see an increase in their stock price during a credible legislative threat event. To check this possibility, I separate the group of treated firms into two subgroups: ‘good’ companies which may be in a position to benefit from an emissions trading scheme, and ‘bad’ companies which may be in a position to lose.

I classify ‘good’ companies as those that made Newsweek’s 2009 Green List. I also examined the list of companies that disclosed carbon emissions information to the Carbon Disclosure Project (CDP) and this list was nearly identical to Newsweek’s Green List. It would be ideal to use carbon emissions information to rank carbon-intensive companies, but the emissions information available through the CDP is noisy - the information is not comparable since there is no standard for what to disclose or requirement that the information be audited. The rationale for this classification of good and bad companies is that the good companies are more likely to be in a position to sell permits (i.e. have a flatter marginal abatement cost curve).

Table 7.12 shows the ordinary least squares estimation of equation (4.2) but where the treated group of companies has been separated into its ‘good’ and ‘bad’ subgroups. The average legislative threat effect is negative for good companies as well as bad, although it is less negative for the good companies. Using a two-tailed t-test to test the hypothesis that there is no difference between the two coefficients, I find that coefficients for the two subgroups are significantly different. That is, for good type companies the legislative threat effect is significantly different than that for bad type companies. Still, it is interesting that there was a negative effect on company value for companies that may benefit from an emissions trading scheme. This result could be because investors are generally uninformed about the carbon emissions status of companies, or that investors see an emissions trading scheme as costly to all companies in the industry.

Table 7.13 shows the ordinary least squares estimation of equation (4.2) where only power plants are included in the sample and where power plants in the RGGI states are the control group. In this case, recession does not significantly impact the effect
of legislative threat for either company type, however there is a significant negative legislative threat effect for the bad-type companies only. Perhaps investors are more knowledgeable about the carbon profiles of power plants – something that may have resulted from the existence of the RGGI emissions trading scheme. Also this may be reflective of the fact that power plants are better able to transfer increased costs to consumers by raising prices than the average company, so that their stock market value is less affected by legislative threat.
Chapter 5

Conclusion

The purpose of my thesis has been to examine the potential for financial markets to act as a mechanism to achieve environmental objectives economically by eliminating the need for costly legislation or regulation. To this end, I first examine the financial market reaction to voluntary overcompliance in order to gain insight into the motivations of investors. At the time of the overcompliance studied (voluntary disclosure of carbon emissions) it may have been generally believed that any costly carbon emissions legislation for companies was unlikely in the foreseeable future, and that actions to reduce emissions would have been unnecessary expenses. Such a belief would lead to negative investor reactions to possibly costly actions. That is, investors may have interpreted disclosure as an informal commitment to increase expenditure on emission reduction projects without justification from any significant legislative threat. As such, it is important to consider that the results of a similar study in another country (one with regulation/legislation in place, for example) may have been different.

Although it seems possible that companies would try to signal low climate change risk through disclosure, the results suggest that in fact investors may not value the efforts of companies to reduce their climate change risk, even for companies in high pollution propensity sectors. Other research on voluntary initiatives similarly found that
voluntary environmental programs are not value maximizing for the company, at least in
the short term (Fisher-Vanden and Thorburn (2008)). This is not to say that the CDP is
inappropriate or counter-productive. Once the Canadian government decides to regulate
carbon emissions, the CDP will be very useful to investors and companies and likely
will aid in the transition to reduced emissions. Without government legislation however,
the results of this dissertation suggest that participation in the CDP through carbon
emissions disclosure is not shareholder-value maximizing. Despite this, some managers
do disclose carbon emissions, possibly due to corporate governance programs or altruistic
management.

To study further the potential for financial markets to encourage environmental over-
compliance, I examine investor reaction to legislative threat of an emissions trading
scheme. My results suggest that legislative threat is less credible during periods of
prolonged recession. Although initially the legislative threat effect was significant, it
decreased in credibility as the depth of the recession became more apparent. There is
at least some evidence that during prolonged economic recession legislative threat is no
longer credible and company value is unaffected. That is, as the depth of the reces-
sion became more apparent, the legislative threat effect was eliminated. Also my results
suggest that since there is no comprehensive and comparable source of information on
company-level carbon emissions investors may not be able to appropriately value compa-
nies in carbon-intensive industries in response to increased legislative threat. Mandatory
public disclosure of this information at both the facility and company level would likely
aid investors in valuing companies, and possibly provide more incentive for companies to
improve their carbon emissions profile.

My theoretical framework indicates that when the legislative threat is strong enough
companies will reduce their carbon emissions in order to prevent implementation of the
threat. It remains for further study however, whether companies actually do respond
to threat of an emissions trading scheme in this way. It also remains for further study
whether a reduction in company value by 18% implies enough credibility to warrant a reduction in carbon emissions, assuming credibility can be maintained. Nevertheless, the results of this study indicate that at the very least, the economic climate should be considered when using legislative threat as a policy tool.

My results suggest that financial markets combined with a credible threat of legislation (or regulation) could provide encouragement to companies to overcomply with current regulations. Before the extent of the economic decline became apparent, I find significant negative financial market reaction for carbon intensive companies when there was a green legislative threat. I also find that investors do not seem to value environmental efforts without significant threat of regulatory or legislative action or some kind of associated financial cost. To know whether companies would reduce their carbon emissions in response to a credible legislative threat combined with negative financial market reaction, more research on factors affecting company carbon emissions levels and intensity is required.

One potential avenue of research would be to estimate the change in carbon emission levels and intensity from a legislative or regulatory threat and associated financial market reaction. One could then determine if this change in emissions levels and intensity represents a Pareto improvement, similar to the research of Maxwell et al. (2000). Depending on the present state of environmental law with respect to carbon emissions, there may be an unambiguous improvement from new legal action. For example, if companies are presently subject to hard caps on emission levels, then an emissions trading scheme could be beneficial for all companies. In this case, the threat of new legislation represents a potential upside risk to the economy.

Another potential avenue of research would be to estimate the socially optimal level of carbon emissions, and the proportion of which that can be optimally allocated to businesses. There are many ways in which such a benchmark could be estimated, and it is probably best that many benchmarks are estimated and compared. A starting point
for comparison may be the emissions targets under the Kyoto protocol. Existing research has compared different policies, including the Kyoto protocol, for welfare implications. In particular, Leach (2009) compared different policies and found that implementation details, such as how rights are allocated, have a significant impact on welfare outcomes.

Another issue raised by Leach (2009) is that the benefit of new climate change policies may not accrue to the generation that bears the costs. The fact that, for some climate change policies, one generation bears the costs while the next benefits suggests that the government will need to play a larger role in reaching an inter-generational optimum. The government can intervene and use threat of new environmental law in order to introduce incentives to companies to move towards the optimal level of carbon emissions. Alternatively, green investing may increase in popularity such that government intervention is unnecessary. The possibility of a high proportion of green investors may lead to other research questions. For example, are investors able to accurately assess the climate change risk and legal risk of a company, such that green investing can successfully invoke polluting companies to reform? At what proportion of green investors does government intervention become unnecessary, and are green investors reaching this critical mass? In the future, the effectiveness of these types of incentives will likely increase since it will become easier for companies to change their production processes to something that is more environmentally friendly, or abate current emissions, as technology improves.

Other research questions could relate to more specific details about new environmental law. In particular, what features of a threat of new environmental law make it more credible? In my thesis I find that for legislative threats in particular, the economic state is an important factor affecting credibility. Future research could explain methods for avoiding a decrease in credibility during economic decline - a problem that may also occur for regulatory agencies who use threat as a policy lever. For example, Brouhle et al. (2009) research the effects of a regulatory threat on the metal-finishing industry in the U.S. which, although it was arguably a significant threat for many years, never
did come to pass because of economic infeasibility. Threats of new environmental law are likely to be more credible if the economic impact of the threatened action is not too negative. Carbon emissions policy needs to balance between environmental sustainability and economic sustainability in order to be effective.
Chapter 6

Appendix

6.1 A Model of Overcompliance as a Signal of Company Value

The following is a proof of the existence of an equilibrium. In equilibrium, a company discloses only if it is a good-type and it has received message $m = 1$, otherwise a company does not disclose.

6.1.1 Critical level of $\varsigma$

Half of all the companies are the good-type, and fraction $q$ of these companies receive the correct message $m = \phi$. If the correct message is $m = 1$ then the proportion of companies that disclose will be $\frac{q}{2}$. If the correct message is $m = 0$ then the proportion of companies that disclose will be $\frac{1-q}{2}$. Therefore either proportion $\frac{q}{2}$ (when $\Phi = 1$) or $\frac{1-q}{2}$ (when $\Phi = 0$) of companies will disclose. Since $\varsigma$ is fully informative about the state of the world, therefore $\Pr(\Phi \mid s, \varsigma) = \Pr(\Phi \mid \varsigma)$. Also since $\varsigma$ is only informative about the state of the world, that is $\varsigma = \frac{q}{2}$ if and only if $\Phi = 1$ and $\varsigma = \frac{1-q}{2}$ if and only if $\Phi = 0$, $\Pr(\tau \mid \Phi, s, \varsigma) = \Pr(\tau \mid \Phi, s)$. Thus the probability $\Pr(\tau, \Phi \mid s, \varsigma)$ can be
represented as:

$$\Pr(\tau, \Phi \mid s, \varsigma) = \Pr(\Phi \mid \varsigma) \cdot \Pr(\tau \mid \Phi, s).$$

### 6.1.2 Consistency with Bayes’ Rule

Let $p(\varsigma \mid \Phi)$ be the probability that the proportion of companies that discloses is equal to $\varsigma$ given the state $\Phi$. The investor’s posterior probabilities and the company’s strategies must be consistent with Bayes’ rule on the equilibrium path. For $\Phi = 1$ when $\frac{q}{2}$:

$$\Pr \left( \Phi = 1 \mid \varsigma = \frac{q}{2} \right) = \frac{p(1)p \left( \frac{q}{2} \mid 1 \right)}{p(1)p \left( \frac{q}{2} \mid 1 \right) + p(0)p \left( \frac{q}{2} \mid 0 \right)} = 1.$$ 

Since $p \left( \frac{q}{2} \mid 0 \right) = 0$, then $\Pr \left( 1 \mid \frac{q}{2} \right) = 1$. This step can be repeated for $\Phi = 0$ and $\frac{1-q}{2}$:

$$\Pr \left( 0 \mid \frac{1-q}{2} \right) = \frac{p(0)p \left( \frac{1-q}{2} \mid 0 \right)}{p(0)p \left( \frac{1-q}{2} \mid 0 \right) + p(1)p \left( \frac{1-q}{2} \mid 1 \right)} = 1.$$ 

Since $p \left( \frac{1-q}{2} \mid 1 \right) = 0$, then $\Pr \left( 0 \mid \frac{1-q}{2} \right) = 1$.

Let $p(s \mid \tau, \Phi)$ be the probability that a company issues signal $s$ given type $\tau$ and state $\Phi$, and recall that the prior over company type is neutral: $p(G) = \frac{1}{2} = p(B)$.

When $\varsigma = \frac{q}{2}$ the future state is $\Phi = 1$. When $s = d$,

$$\Pr(\tau = G \mid s = d, \Phi = 1) = \frac{p(G)p(d \mid G, 1)}{p(G)p(d \mid G, 1) + p(B)p(d \mid B, 1)} = 1,$$

since $p(d \mid B, 1) = 0$. When $\varsigma = \frac{1-q}{2}$ the future state is $\Phi = 0$. When $s = d$,

$$\Pr(\tau = G \mid s = d, \Phi = 0) = \frac{p(G)p(d \mid G, 0)}{p(G)p(d \mid G, 0) + p(B)p(d \mid B, 0)} = 1,$$
since \( p(d \mid B, 0) = 0 \). Repeating these steps for \( s = n \):

\[
\Pr(B \mid n, 1) = \frac{p(B)p(n \mid B, 1)}{p(G)p(n \mid G, 1) + p(B)p(n \mid B, 1)} = \frac{1}{\frac{1}{2} \cdot 1} = \frac{1}{2 - q},
\]

where \( p(n \mid G, 1) = \Pr(m = 0 \mid G, \Phi = 1) = \Pr(m = 0 \mid \Phi = 1) = (1 - q) \), and

\[
\Pr(G \mid n, 1) = \frac{p(G)p(n \mid G, 1)}{p(G)p(n \mid G, 1) + p(B)p(n \mid B, 1)} = \frac{1}{\frac{1}{2} \cdot (1 - q) + \frac{1}{2} \cdot 1} = \frac{1 - q}{2 - q}.
\]

When \( \varsigma = \frac{1 - q}{2} \) and \( s = n \),

\[
\Pr(B \mid n, 0) = \frac{p(B)p(n \mid B, 0)}{p(G)p(n \mid G, 0) + p(B)p(n \mid B, 0)} = \frac{1}{\frac{1}{2} \cdot 1} = \frac{1}{1 + q},
\]

and

\[
\Pr(G \mid n, 0) = \frac{p(G)p(n \mid G, 0)}{p(G)p(n \mid G, 0) + p(B)p(n \mid B, 0)} = \frac{q}{1 + q},
\]

where \( p(n \mid G, 0) = \Pr(m = 0 \mid G, \Phi = 0) = \Pr(m = 0 \mid \Phi = 0) = q \). Therefore investors’ posterior beliefs and the company’s strategies are consistent with Bayes’ rule.
6.1.3 A Company’s Incentive to Disclose

Let \( y(\tau, m) \) be the difference in payoffs for a company between disclosing and not disclosing. Based on equation (2.1), a company’s excess payoff from issuing signal \( d \) over \( n \), given its private information, is

\[
y(\tau, m) = E[P_t(d, \varsigma) - P_t(n, \varsigma) \mid \tau, m] + E[v(d, \tau, \Phi) - v(n, \tau, \Phi) \mid \tau, m].
\]

When a company receives the \( m = 1 \), it believes that \( \Phi = 1 \) with probability \( q \) and hence believes that \( \varsigma \) will be equal to \( q^2 \) with probability \( q \). When a company receives the message \( m = 0 \), it believes that \( \Phi = 0 \) with probability \( q \) and hence believes that \( \varsigma \) will be equal to \( 1 - q^2 \) with probability \( q \). The aim of this section is to show that when a company receives message \( m = 1 \), then the company only has an incentive to disclose when it is a good-type \( (\tau = G) \), and when a company receives message \( m = 0 \) it has no incentive to disclose. When \( m = 1 \)

\[
y(\tau, 1) = E[P_t(d, \varsigma) - P_t(n, \varsigma) \mid \tau, m] + E[v(d, \tau, \Phi) - v(n, \tau, \Phi) \mid \tau, m] \\
= E[P_t(d, \varsigma) - P_t(n, \varsigma) \mid \tau, m] + [q \cdot (v(d, \tau, 1) - v(n, \tau, 1)) + (1 - q) \cdot (v(d, \tau, 0) - v(n, \tau, 0))] \\
= E[P_t(d, \varsigma) - P_t(n, \varsigma) \mid \tau, m] + [(v(d, \tau, 1) - v(n, \tau, 1))] \\
= [q \cdot v(d, G, 1) + (1 - q) \cdot v(d, G, 0)] - q \cdot \left[ \frac{1 - q}{2 - q} v(n, G, 1) + \frac{1}{2 - q} v(n, B, 1) \right] - (1 - q) \cdot \left[ \frac{q}{1 + q} v(n, G, 0) + \frac{1}{1 + q} v(n, B, 0) \right] \\
+ [(v(d, \tau, 1) - v(n, \tau, 1))] \\
= [q \cdot v(d, G, 1) + (1 - q) \cdot v(d, G, 0)] - q \cdot \left[ \frac{1 - q}{2 - q} v(n, G, 1) + \frac{1}{2 - q} v(n, B, 1) \right] - (1 - q) \cdot v(n, G, 0) + [(v(d, \tau, 1) - v(n, \tau, 1))] \\
\]

which can be represented as

\[
y(\tau, 1) = q \cdot \left[ v(d, G, 1) - \frac{1 - q}{2 - q} v(n, G, 1) - \frac{1}{2 - q} v(n, B, 1) \right] + (1 - q) \cdot [v(d, G, 0) - v(n, G, 0)] \\
+ [v(d, \tau, 1) - v(n, \tau, 1)]. \tag{6.1}
\]

To determine how changes in \( q \) affect \( y(\tau, 1) \), I take the partial derivative of \( y(\tau, 1) \) with respect to \( q \):

\[
\frac{\partial y(\tau, 1)}{\partial q} = v(d, G, 1) - \frac{2 + q^2 - 4q}{(2 - q)^2} v(n, G, 1) - \frac{2}{(2 - q)^2} v(n, B, 1) + [v(n, G, 0) - v(d, G, 0)] > 0.
\]
Where the inequality follows by (2.3), (2.4) and (2.6), and consequently \( y(\tau, 1) \) is increasing in \( q \) \( \forall q \in (\frac{1}{2}, 1) \).

Using the investor’s decision rules and substituting for \( \tau = G \) in equation (6.3)

\[
y(G, 1) = q \cdot \left[ v(d, G, 1) - \frac{1}{2 - q} v(n, G, 1) - \frac{1}{2 - q} v(n, B, 1) \right] + (2 - q) \cdot [v(d, G, 1) - v(n, G, 1)],
\]

by (2.3). When \( q = 1 \):

\[
y(G, 1) = 2 \cdot v(d, G, 1) - v(n, G, 1) - \frac{1}{2} v(n, B, 1) > 0
\]

by (2.7) and when \( q = \frac{1}{2} \):

\[
y(G, 1) = \left[ \frac{1}{2} v(d, G, 1) - \frac{1}{6} v(n, G, 1) - \frac{1}{3} v(n, B, 1) \right] + \frac{3}{2} \cdot [v(d, G, 1) - v(n, G, 1)]
\]

\[
= 2 \cdot v(d, G, 1) - \frac{5}{3} v(n, G, 1) - \frac{1}{3} v(n, B, 1) = 0
\]

by (2.7). Since \( y(G, 1) \) is monotonically increasing in \( q \), therefore \( y(G, 1) > 0 \) \( \forall q \in (\frac{1}{2}, 1) \).

Using the investor’s decision rules and substituting for \( \tau = B \) in equation (6.3)

\[
y(B, 1) = q \cdot \left[ v(d, B, 1) - \frac{1 - q}{2 - q} v(n, G, 1) - \frac{1}{2 - q} v(n, B, 1) \right] + (1 - q) \cdot [v(d, G, 0) - v(n, G, 0)]
\]

\[
+ [v(d, B, 1) - v(n, B, 1)].
\]

When \( q = 1 \):

\[
y(B, 1) = v(d, G, 1) + v(d, B, 1) - \frac{3}{2} v(n, B, 1) < 0
\]

by (2.7) and when \( q = \frac{1}{2} \):

\[
y(B, 1) = v(d, B, 1) + \frac{1}{2} v(d, G, 1) + \frac{1}{2} v(d, G, 0) - \frac{1}{6} v(n, G, 1) - \frac{1}{3} v(n, B, 1) - \frac{1}{2} v(n, G, 0) < 0
\]

by (2.3), (2.4) and (2.7). Since \( y(B, 1) \) is monotonically increasing in \( q \), therefore \( y(B, 1) < 0 \) \( \forall q \in (\frac{1}{2}, 1) \).
When \( m = 0 \)

\[
y(\tau, 0) = E[P_t(d, \varsigma) - P_t(n, \varsigma) \mid \tau, m] + E[v(d, \tau, \Phi) - v(n, \tau, \Phi) \mid \tau, m] \\
= E[P_t(d, \varsigma) - P_t(n, \varsigma) \mid \tau, m] + [q \cdot (v(d, \tau, 0) - v(n, \tau, 0)) + (1 - q) \cdot (v(d, \tau, 1) - v(n, \tau, 1))] \\
= E[P_t(d, \varsigma) - P_t(n, \varsigma) \mid \tau, m] + \left[ (v(d, \tau, 1) - v(n, \tau, 1)) \right] \\
= [q \cdot v(d, G, 0) + (1 - q) \cdot v(d, G, 1)] - (1 - q) \cdot \left[ \frac{1 - q}{2 - q} v(n, G, 1) + \frac{1}{2 - q} v(n, B, 1) \right] - q \cdot \left[ \frac{q}{1 + q} v(n, G, 0) + \frac{1}{1 + q} v(n, B, 0) \right] \\
+ \left[ (v(d, \tau, 1) - v(n, \tau, 1)) \right] \\
= [q \cdot v(d, G, 0) + (1 - q) \cdot v(d, G, 1)] - (1 - q) \cdot \left[ \frac{1 - q}{2 - q} v(n, G, 1) + \frac{1}{2 - q} v(n, B, 1) \right] - q \cdot v(n, G, 0) + \left[ (v(d, \tau, 1) - v(n, \tau, 1)) \right]
\]

which can be represented as

\[
y(\tau, 0) = q \cdot [v(d, G, 0) - v(n, G, 0)] + (1 - q) \cdot \left[ v(d, G, 1) - \frac{1 - q}{2 - q} v(n, G, 1) - \frac{1}{2 - q} v(n, B, 1) \right] + \left[ v(d, \tau, 1) - v(n, \tau, 1) \right].
\]

(6.2)

To determine how changes in \( q \) affect \( y(\tau, 0) \), I take the partial derivative of \( y(\tau, 0) \) with respect to \( q \):

\[
\frac{\partial y(\tau, 0)}{\partial q} = [v(d, G, 0) - v(n, G, 0)] - v(d, G, 1) + \frac{q^2 - 4q + 2}{(2 - q)^2} v(n, G, 1) + \frac{2}{(2 - q)^2} v(n, B, 1) < 0.
\]

Where the inequality follows by (2.3), (2.4) and (2.6), and consequently \( y(\tau, 0) \) is decreasing in \( q \) \( \forall q \in (\frac{1}{2}, 1) \).

Using the investor’s decision rules and substituting for \( \tau = G \) in equation (6.2)

\[
y(G, 0) = (1 - q) \cdot \left[ v(d, G, 1) - \frac{1 - q}{2 - q} v(n, G, 1) - \frac{1}{2 - q} v(n, B, 1) \right] + (1 + q) \cdot \left[ v(d, G, 1) - v(n, G, 1) \right]
\]

by (2.3). When \( q = 1 \):

\[
y(G, 0) = 2 [v(d, G, 1) - v(n, G, 1)] < 0
\]

by (2.3) and when \( q = \frac{1}{2} \):

\[
y(G, 0) = \left[ \frac{1}{2} \cdot v(d, G, 1) - \frac{1}{6} v(n, G, 1) - \frac{1}{3} v(n, B, 1) \right] + \frac{3}{2} \cdot [v(d, G, 1) - v(n, G, 1)] \\
= 2 \cdot v(d, G, 1) - \frac{5}{3} v(n, G, 1) - \frac{1}{3} v(n, B, 1) = 0
\]
by (2.7). Since \( y(G, 0) \) is monotonically decreasing in \( q \), therefore \( y(G, 0) < 0 \ \forall q \in (\frac{1}{2}, 1) \).

Using the investor’s decision rules and substituting for \( \tau = B \) in equation (6.3)

\[
y(B, 0) = (1 - q) \cdot \left[ v(d, G, 1) - \frac{1 - q}{2 - q} v(n, G, 1) - \frac{1}{2 - q} v(n, B, 1) \right] + q \cdot [v(d, G, 1) - v(n, G, 1)] + [v(d, B, 1) - v(n, B, 1)].
\]

When \( q = 1 \):

\[
y(B, 0) = [v(d, G, 1) - v(n, G, 1)] + [v(d, B, 1) - v(n, B, 1)] < 0
\]

by (2.3) and (2.4) and when \( q = \frac{1}{2} \):

\[
y(B, 0) = \left[ \frac{1}{2} \cdot v(d, G, 1) - \frac{1}{6} v(n, G, 1) - \frac{1}{3} v(n, B, 1) \right] + \frac{1}{2} \cdot [v(d, G, 1) - v(n, G, 1)] + [v(d, B, 1) - v(n, B, 1)]
\]

\[
= v(d, G, 1) + v(d, B, 1) - \frac{2}{3} v(n, G, 1) - \frac{4}{3} v(n, B, 1) < 0
\]

by (2.4), (2.3) and (2.7). Since \( y(B, 0) \) is monotonically increasing in \( (1 - q) \), therefore \( y(B, 0) < 0 \ \forall q \in (\frac{1}{2}, 1) \). Since \( y(B, 0) \), \( y(G, 0) \), and \( y(B, 1) \) are all less than zero, a company only discloses when \( m = 1 \) and when \( \tau = G \) where \( y(G, 1) > 0 \).
6.2 A Model of Overcompliance as Pre-emption

In the model, each company is uncertain about what the other company will do as well as what the government will do. To solve for the symmetric mixed strategy equilibrium, I set the expected payoff of a company that does not pollute equal to the expected payoff of a company that does pollute

\[ \pi_0 = \pi_p - \rho(\Psi^{**} - \Psi^*)c - \Psi^*c, \]  
\[ (6.3) \]

where the left hand side is the certain payoff to a company that chooses not to pollute, and the right hand side is the expected payoff from polluting. First I gather all terms with \( \rho \) on one side,

\[ \pi_p - \pi_0 - \Psi^*c = \rho(\Psi^{**} - \Psi^*)c, \]  
\[ (6.4) \]

and then I isolate \( \rho \),

\[ \rho^* = \frac{\pi_p - \pi_0 - \Psi^*c}{(\Psi^{**} - \Psi^*)c}, \]  
\[ (6.5) \]

which is the same as in equation (2.9).

Solving equation (2.9) for \( \rho^* \geq 1 \) results in

\[ \pi_p - \pi_0 - \Psi^*c \geq (\Psi^{**} - \Psi^*)c, \]  
\[ (6.6) \]

which can be rewritten as

\[ \pi_p - \pi_0 \geq \Psi^{**}c. \]  
\[ (6.7) \]

A company plays a pure strategy (\( \rho = 1 \)) when the inequality (6.7) holds.

Solving equation (2.9) for \( \rho^* \leq 0 \) results in

\[ \pi_p - \pi_0 - \Psi^*c \leq 0, \]  
\[ (6.8) \]
which can be rewritten as
\[ \pi_p - \pi_0 \leq \Psi^* c. \tag{6.9} \]

A company plays a pure strategy (\( \rho = 0 \)) when the inequality (6.9) holds.

Solving equation (2.9) for \( 0 < \rho^* < 1 \) results in
\[ \Psi^* c < \pi_p - \pi_0 < \Psi^{**} c. \tag{6.10} \]

A company plays a mixed strategy (\( \rho \in (0, 1) \)) when the inequality (6.10) holds.
6.3 CDP4 Questionnaire

1. General: How does climate change represent commercial risks and/or opportunities for your company?

2. Regulation: What are the financial and strategic impacts on your company of existing regulation of GHG emissions, and what do you estimate to be the impact of proposed future regulation?

3. Physical risks: How are your operations affected by extreme weather events, changes in weather patterns, rising temperatures, sea level rise and other related phenomena, both now and in the future? What actions are you taking to adapt to these risks, and what are the associated financial implications?

4. Innovation: What technologies, products, processes or services has your company developed, or is developing, in response to climate change?

5. Responsibility: Who at board level has specific responsibility for climate-change-related issues, and who manages your company’s climate-change strategies? How do you communicate the risks and opportunities from GHG emissions and climate change in your annual report and other communications channels?

6. Emissions: What is the quantity in tonnes $CO_2$ of annual emissions of the six main GHGs produced by your owned and controlled facilities in the following areas, listing data by country? (To assist in comparing responses, please state which methodology you are using for calculating emissions and the boundaries selected for emissions reporting. Please standardize your response data to be consistent with the accounting approach employed by the GHG Protocol (www.ghgprotocol.org). Please list GHG Protocol scope 1, 2 and 3 emissions equivalent showing full details of the sources. How has this data been audited and/or externally verified?)
• Globally.
• Annex B countries of the Kyoto Protocol.
• EU Emissions Trading Scheme.

7. Products and services: What are your estimated emissions in tonnes CO2e associated with the following areas? Please explain the calculation methodology employed.
• Use and disposal of your products and services.
• Your supply chain.

8. Emissions reduction: What is your firm’s current emissions reduction strategy? How much investment have you committed to its implementation, what are the costs/profits, what are your emissions reduction targets and time frames to achieve them?

9. Emissions trading: What is your firm’s strategy for, and expected cost/profit from, trading in the EU Emissions Trading Scheme, CDM/JI projects and other trading systems, where relevant?

10. Energy costs: What are the total costs of your energy consumption (e.g., fossil fuels, electric power)? Please quantify the potential impact on profitability from changes in energy prices and consumption.

11. For electric utilities: Explain to what extent current and future emissions reductions involve a change of use in existing assets (i.e., fuel switching at existing facilities) or a need for new investment? What percentage of your revenue is derived from renewable generation in a government-sponsored price support mechanism?
Chapter 7

Tables and Figures

Figure 7.1: The True Value of a Company. This figure illustrates true value of the company given the signal chosen by the company, the company type, and the future state of legislation \( v(s, \theta, \Phi) \). Investors do not know the future state nor the company type, but they do know that the true value of the company is one of these eight values. Once investors observe the company’s signal, they know that the true value of the company is one of four possible values.
Figure 7.2: Structure of the Model with Legislative Threat. This figure illustrates the actions of the companies and the government and their potential payoffs.
Figure 7.3: **U.S. Real GDP and the Cumulative Difference in GDP from the Peak.** The GDP level is represented in 10’s of trillions of U.S. dollars. The cumulative difference from peak level of GDP starts at zero when GDP is at its peak level, and decreases to minimum when GDP reaches the peak level again, and returns to zero when GDP reaches a level more consistent with the pre-recession trend.
### Table 7.1: Ex-ante Characteristics of Sample Companies

Notes: This table represents the summary statistics for all companies in the sample. Variables are from Compustat (unless otherwise specified) and are measured at the end of the fiscal year 2005. Industries are based on SIC codes as indicated by Compustat. The t-test tests the hypothesis that there is no difference between the means of the subsamples, and is an unequal sample size, unequal variance, two-tailed test. Significance at the 5% level is indicated by *.

<table>
<thead>
<tr>
<th>End of 2005 Characteristics</th>
<th>(1)</th>
<th>(2)</th>
<th>(1) - (2)</th>
<th>t-stat</th>
<th>(3)</th>
<th>(4)</th>
<th>(3) - (4)</th>
<th>t-stat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All firms</td>
<td>CDP4</td>
<td>Difference</td>
<td>t-stat</td>
<td>Disclosed</td>
<td>Withheld</td>
<td>Difference</td>
<td>t-stat</td>
</tr>
<tr>
<td>Market value of equity</td>
<td>Mean 2,214.8</td>
<td>5,716.7</td>
<td>72.5</td>
<td>0.09</td>
<td>13,424.0</td>
<td>3,695.9</td>
<td>9,728.1</td>
<td>4.14*</td>
</tr>
<tr>
<td>($ million)</td>
<td>N 645</td>
<td>207</td>
<td>43</td>
<td>164</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Sales</td>
<td>Mean 1,697.1</td>
<td>3,767.8</td>
<td>-2,070.7</td>
<td>-4.36*</td>
<td>7,487.5</td>
<td>2,792.5</td>
<td>4,695.0</td>
<td>3.52*</td>
</tr>
<tr>
<td>($ million)</td>
<td>N 647</td>
<td>207</td>
<td>43</td>
<td>164</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Book-to-Market ratio</td>
<td>Mean 0.99</td>
<td>0.50</td>
<td>0.4959</td>
<td>1.86</td>
<td>0.47</td>
<td>0.51</td>
<td>-0.0380</td>
<td>-0.55</td>
</tr>
<tr>
<td></td>
<td>N 645</td>
<td>207</td>
<td>43</td>
<td>164</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily Volatility</td>
<td>Mean 0.1019</td>
<td>0.0763</td>
<td>0.0256</td>
<td>7.81*</td>
<td>0.0724</td>
<td>0.0773</td>
<td>-0.0049</td>
<td>-1.03</td>
</tr>
<tr>
<td>Source: Calculated from CFMRC data</td>
<td>N 877</td>
<td>208</td>
<td>43</td>
<td>165</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Capital raised by the Firm</td>
<td>Mean 0.1126</td>
<td>0.0289</td>
<td>0.0837</td>
<td>7.84*</td>
<td>0.0049</td>
<td>0.0359</td>
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<td>-2.14*</td>
</tr>
<tr>
<td>($ million)</td>
<td>N 559</td>
<td>173</td>
<td>39</td>
<td>134</td>
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<td></td>
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<tr>
<td>Tobin’s Q</td>
<td>Mean 6.46</td>
<td>3.21</td>
<td>3.2418</td>
<td>3.70*</td>
<td>2.15</td>
<td>3.50</td>
<td>-1.3487</td>
<td>-1.72*</td>
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<td>Market value/surplus value</td>
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<td>39</td>
<td>147</td>
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<tr>
<td>Asset Newness</td>
<td>Mean 0.62</td>
<td>0.62</td>
<td>-0.0023</td>
<td>-0.16</td>
<td>0.58</td>
<td>0.63</td>
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<td>net PP&amp;E/gross PP&amp;E</td>
<td>N 595</td>
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<td>42</td>
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<tr>
<td>Capital Intensity</td>
<td>Mean 3.82</td>
<td>1.82</td>
<td>2.0028</td>
<td>0.93</td>
<td>0.17</td>
<td>2.27</td>
<td>-2.1012</td>
<td>-1.16</td>
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<td>capital spending</td>
<td>N 575</td>
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<td>43</td>
<td>160</td>
<td></td>
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<tr>
<td>% of Market Capitalization</td>
<td>Mean 12.61</td>
<td>14.03</td>
<td>12.24</td>
<td>1.79</td>
<td>1.56</td>
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<tr>
<td>Owned by CDP signatories</td>
<td>N 203</td>
<td>42</td>
<td>161</td>
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<tr>
<td>Environmental Performance</td>
<td>Mean 5.17</td>
<td>5.57</td>
<td>5.04</td>
<td>0.53</td>
<td>3.41*</td>
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<tr>
<td>(Score out of max of 10)</td>
<td>N 146</td>
<td>35</td>
<td>111</td>
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<tr>
<td>% of Firms that have facilities which have disclosed emissions to the government</td>
<td>16.35</td>
<td>44.19</td>
<td>9.09</td>
<td>35.10</td>
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<tr>
<td>Source: National GHG Inventory</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>% of sample firms in the industry of: Manufacturing</td>
<td>22.58</td>
<td>29.81</td>
<td>-7.23</td>
<td>39.53</td>
<td>27.27</td>
<td>12.26</td>
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<td>Mining</td>
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<td>27.91</td>
<td>24.85</td>
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<tr>
<td>Transportation &amp; Utilities</td>
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<td>13.94</td>
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<td>11.52</td>
<td>11.74</td>
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<tr>
<td>Other</td>
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<td>30.77</td>
<td>9.30</td>
<td>36.36</td>
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<td></td>
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<tr>
<td>Total</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 7.2: Covariate Correlations for Canadian Companies Surveyed by the CDP in 2006

Notes: This table represents correlations for the CDP4 sample only. The covariates represent company-level data at the end of 2005, prior to being surveyed by the Carbon Disclosure Project.

<table>
<thead>
<tr>
<th>Covariates</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log of Total Assets</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Book-to-Market Ratio</td>
<td>-0.089</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volatility</td>
<td>-0.482</td>
<td>0.076</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital Raised by the Firm</td>
<td>-0.133</td>
<td>-0.071</td>
<td>0.142</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tobin’s Q</td>
<td>-0.106</td>
<td>-0.130</td>
<td>-0.049</td>
<td>0.077</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asset Newness</td>
<td>-0.393</td>
<td>-0.029</td>
<td>0.392</td>
<td>0.232</td>
<td>-0.112</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital Intensity</td>
<td>-0.269</td>
<td>-0.111</td>
<td>0.452</td>
<td>0.267</td>
<td>-0.006</td>
<td>0.357</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share of Market Cap owned by CDP signatories</td>
<td>0.042</td>
<td>-0.282</td>
<td>0.088</td>
<td>0.043</td>
<td>0.056</td>
<td>0.112</td>
<td>0.066</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Jantzi Research Environmental Performance Score</td>
<td>0.235</td>
<td>-0.118</td>
<td>-0.113</td>
<td>-0.035</td>
<td>-0.007</td>
<td>-0.145</td>
<td>0.040</td>
<td>0.220</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Table 7.3: Probit estimation of the Propensity to Disclose 2005 Annual Carbon Emissions to the Carbon Disclosure Project

Notes: This table shows the results from estimations of the probit model of the propensity to disclose carbon emissions to the CDP using the CDP4 sample data: $D^* = \delta' z_i + \xi_i$. Standard errors are in parentheses. Model 4 is estimated without the environmental performance variable in order to increase the sample size. In this table, significance at the 10% level is indicated by *, significance at the 5% level is indicated by **, and significance at the 1% level is indicated by ***.

<table>
<thead>
<tr>
<th></th>
<th>[1]</th>
<th>[2]</th>
<th>[3]</th>
<th>[4]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Log of Total Assets</td>
<td>0.347***</td>
<td>0.358***</td>
<td>0.405***</td>
<td>0.460***</td>
</tr>
<tr>
<td></td>
<td>(0.13)</td>
<td>(0.11)</td>
<td>(0.10)</td>
<td>(0.09)</td>
</tr>
<tr>
<td>1 if Reported Carbon Emissions to Government</td>
<td>0.748*</td>
<td>0.638*</td>
<td>0.690**</td>
<td>0.642**</td>
</tr>
<tr>
<td></td>
<td>(0.39)</td>
<td>(0.34)</td>
<td>(0.32)</td>
<td>(0.28)</td>
</tr>
<tr>
<td>1 if Manufacturing, Mining, Utilities and Transportation</td>
<td>1.637***</td>
<td>1.494***</td>
<td>1.667***</td>
<td>1.756***</td>
</tr>
<tr>
<td></td>
<td>(0.63)</td>
<td>(0.55)</td>
<td>(0.54)</td>
<td>(0.49)</td>
</tr>
<tr>
<td>Jantzi Environmental Performance Score</td>
<td>0.183</td>
<td>0.271</td>
<td>0.338**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.19)</td>
<td>(0.17)</td>
<td>(0.16)</td>
<td></td>
</tr>
<tr>
<td>Capital Raised by the Company</td>
<td>0.211</td>
<td>-0.875</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.03)</td>
<td>(1.91)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion of Company Owned by CDP Signatories</td>
<td>2.847</td>
<td>1.816</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.33)</td>
<td>(2.15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Book-to-Market Ratio</td>
<td>-0.669</td>
<td>-0.270</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.72)</td>
<td>(0.65)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tobin’s Q</td>
<td>0.013</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.03)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005 Return Volatility</td>
<td>2.944</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(6.02)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asset Newness</td>
<td>-1.336</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.13)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital Intensity</td>
<td>-0.151</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.48)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-5.549**</td>
<td>-6.523***</td>
<td>-7.370***</td>
<td>-6.138***</td>
</tr>
<tr>
<td></td>
<td>(2.17)</td>
<td>(1.59)</td>
<td>(1.44)</td>
<td>(1.07)</td>
</tr>
</tbody>
</table>

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudo $R^2$</td>
<td>0.3092</td>
<td>0.2930</td>
<td>0.3270</td>
<td>0.3085</td>
</tr>
<tr>
<td>Number of observations</td>
<td>105</td>
<td>121</td>
<td>145</td>
<td>207</td>
</tr>
<tr>
<td>Percent correct predictions</td>
<td>82.86</td>
<td>80.99</td>
<td>82.76</td>
<td>82.13</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-42.06</td>
<td>-49.42</td>
<td>-53.93</td>
<td>-73.14</td>
</tr>
<tr>
<td>LR chi2(3)</td>
<td>37.65</td>
<td>40.95</td>
<td>52.41</td>
<td>65.25</td>
</tr>
<tr>
<td>p-value</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Average Inverse Mills Ratio for firms that disclosed emissions ($\lambda_d I_d$)</td>
<td>.8398</td>
<td>.8649</td>
<td>.8595</td>
<td>.9497</td>
</tr>
<tr>
<td>Average Inverse Mills Ratio for firms that withheld emissions ($\lambda_n I_n$)</td>
<td>-.3054</td>
<td>-.3110</td>
<td>-.2735</td>
<td>-.2490</td>
</tr>
</tbody>
</table>
Table 7.4: Estimates of Average Abnormal Returns from Carbon Emissions Disclosure

Notes: This table represents maximum likelihood estimates from panel regressions with bootstrapped standard errors, and represents regression (3.13):

\[ R_{it} = E[R_{it} | Y_t] + \pi [\lambda_d I_{di}] + \pi [\lambda_n I_{ni}] + \pi g I_{gi} + \nu_{it} \]

The ten-day event window are the ten trading days from May 30 to June 12, 2006. The value of \( E[R_{it} | Y_t] \) was calculated using the market model. The cross-sectional data include companies from the CDP4 sample, as well as a random selection of about 30 companies not in the CDP4 sample but in the Full sample from the CFRMC database. In this table, significance at the 10% level is indicated by *, significance at the 5% level is indicated by **, and significance at the 1% level is indicated by ***.

<table>
<thead>
<tr>
<th>Event Window: May 30 - June 12, 2006 (10 trading days)</th>
<th>[1]</th>
<th>[2]</th>
<th>[3]</th>
<th>[4]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not in CDP4 sample ((I_g))</td>
<td>-0.0014</td>
<td>-0.0014</td>
<td>-0.0014</td>
<td>-0.0014</td>
</tr>
<tr>
<td></td>
<td>(0.0020)</td>
<td>(0.0020)</td>
<td>(0.0019)</td>
<td>(0.0019)</td>
</tr>
<tr>
<td>Selection Hazard 1 ((\hat{\lambda})^a)</td>
<td>-0.0017**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0007)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection Hazard 2 ((\hat{\lambda})^b)</td>
<td></td>
<td>-0.0014**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0007)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection Hazard 3 ((\hat{\lambda})^c)</td>
<td></td>
<td></td>
<td>-0.0014*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0008)</td>
<td></td>
</tr>
<tr>
<td>Selection Hazard 4 ((\hat{\lambda})^d)</td>
<td></td>
<td></td>
<td></td>
<td>-0.0013**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.0005)</td>
</tr>
</tbody>
</table>

Mean daily abnormal returns from:
- Disclosing Carbon Emissions: -0.0013, -0.0012, -0.0012, -0.0013
- Withholding Carbon Emissions: 0.0005, 0.0004, 0.0004, 0.0003

Mean daily change in market value ($ millions) from:
- Disclosing Carbon Emissions: -12.65, -11.64, -11.05, -10.20
- Withholding Carbon Emissions: 4.02, 3.80, 3.10, 2.39
Table 7.5: Estimates of Average Abnormal Returns from Carbon Emissions Disclosure Manufacturing, Mining, Utilities and Transportation Companies Only

Notes: This table represents maximum likelihood estimates from panel regressions with bootstrapped standard errors, and represents regression (3.13): 

\[ R_{it} = E[R_{it} | Y_t] + \pi_1 \lambda_{it} I_{id} + \pi_2 \lambda_{it} I_{ni} + \pi_3 g_i I_{gi} + \nu_{it} \]

The ten-day event window are the ten trading days from May 30 to June 12, 2006. The value of \( E[R_{it} | Y_t] \) was calculated using the market model. The cross-sectional data include companies in the manufacturing, mining, utilities and transportation sectors in the CDP4 sample, as well as a random selection of about 30 companies not in the CDP4 sample but in the Full sample from the CFEMC database. In this table, significance at the 10% level is indicated by *, significance at the 5% level is indicated by **, and significance at the 1% level is indicated by ***.

\(^a\) Selection hazard estimated from results of probit regression of the natural log of total assets, reported emissions to government, manufacturing, mining, utilities or transportation company, environmental performance score, capital raised, proportion of company owned by CDP signatories, book-to-market ratio, Tobin’s Q, 2005 stock return volatility, asset newness, and capital intensity on a binary variable equal to one if the company disclosed carbon emissions.

\(^b\) Selection hazard estimated from results of probit regression of the natural log of total assets, reported emissions to government, manufacturing, mining, utilities or transportation company, environmental performance score, capital raised, proportion of company owned by CDP signatories, and book-to-market ratio on a binary variable equal to one if the company disclosed carbon emissions.

\(^c\) Selection hazard estimated from results of probit regression of the natural log of total assets, reported emissions to government, manufacturing, mining, utilities or transportation company, and an environmental performance score on a binary variable equal to one if the company disclosed carbon emissions.

\(^d\) Selection hazard estimated from results of probit regression of the natural log of total assets, reported emissions to government, and manufacturing, mining, utilities or transportation company on a binary variable equal to one if the company disclosed carbon emissions.

<table>
<thead>
<tr>
<th>Event Window: May 30 - June 12, 2006 (10 trading days)</th>
<th>[1]</th>
<th>[2]</th>
<th>[3]</th>
<th>[4]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not in CDP4 sample (I_g)</td>
<td>-0.0047*** (0.0014)</td>
<td>-0.0047** (0.0019)</td>
<td>-0.0047*** (0.0014)</td>
<td>-0.0047*** (0.0016)</td>
</tr>
<tr>
<td>Selection Hazard 1 ((\hat{\lambda}))^a</td>
<td>-0.0017* (0.0009)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection Hazard 2 ((\hat{\lambda}))^b</td>
<td>-0.0014 (0.0009)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection Hazard 3 ((\hat{\lambda}))^c</td>
<td>-0.0014** (0.0006)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection Hazard 4 ((\hat{\lambda}))^d</td>
<td>-0.0013** (0.0005)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mean daily abnormal returns from:**
- Disclosing Carbon Emissions: -0.0013
- Withholding Carbon Emissions: 0.0005

**Mean daily change in market value (\$ millions) from:**
- Disclosing Carbon Emissions: -12.65
- Withholding Carbon Emissions: 4.02

**Mean daily change in market value (\$ millions) from:**
- Disclosing Carbon Emissions: 3.80
- Withholding Carbon Emissions: 3.10
Table 7.6: Estimates of Average Abnormal Returns from Carbon Emissions Disclosure Using Fama-French Three-Factor Model to Estimate ‘Normal Returns’

Notes: This table represents maximum likelihood estimates from panel regressions with bootstrapped standard errors, and represents regression (3.13):

\[ R_{it} = E[R_{it} | Y_t] + \pi[\lambda_{id_i} I_{di}] + \pi[\lambda_{ni} I_{ni}] + \pi g_i I_{gi} + \nu_{it} \]

The ten day event window are the 106 trading days from February 1 to June 30, 2006. The value of \( E[R_{it} | Y_t] \) was calculated using the Fama-French three-factor model. The cross-sectional data include companies from the CDP4 sample, as well as a random selection of about 30 companies not in the CDP4 sample but in the Full sample from the CFRMC database. In this table, significance at the 15% level is indicated by *, significance at the 10% level is indicated by **, and significance at the 5% level is indicated by ***.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Not in CDP4 sample ( (I_g) )</td>
<td>0.0002</td>
<td>0.0002</td>
<td>0.0002</td>
<td>0.0002</td>
</tr>
<tr>
<td>( )</td>
<td>( (0.0005) )</td>
<td>( (0.0004) )</td>
<td>( (0.0004) )</td>
<td>( (0.0004) )</td>
</tr>
<tr>
<td>Selection Hazard 1 ( (\hat{\lambda})^a )</td>
<td>-0.0002</td>
<td>( (0.0002) )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection Hazard 2 ( (\hat{\lambda})^b )</td>
<td>( -0.0001 )</td>
<td>( (0.0002) )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection Hazard 3 ( (\hat{\lambda})^c )</td>
<td>( -0.0002 )</td>
<td>( (0.0002) )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection Hazard 4 ( (\hat{\lambda})^d )</td>
<td>( -0.0003* )</td>
<td>( (0.0002) )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean daily abnormal returns from:
- Disclosing Carbon Emissions: -0.0001 -0.0001 -0.0002 -0.0003
- Withholding Carbon Emissions: 0.0001 0.0000 0.0001 0.0001

Mean daily change in market value ($ millions) from:
- Disclosing Carbon Emissions: -1.39 -0.89 -1.55 -2.31
- Withholding Carbon Emissions: 0.44 0.30 0.46 0.56
Table 7.7: Summary Statistics for Companies from Q4 2006 to Q3 2010

Notes: All data is from Compustat from Q4 2006 to Q3 2010 (16 quarters). Tobin’s Q is calculated at quarter end as the sum of common stock, debt and preferred stock, divided by the sum of property, plant and equipment, inventories, cash and short term investments and receivables.

<table>
<thead>
<tr>
<th></th>
<th>Tobin’s Q</th>
<th>Log of Total Assets</th>
<th>Debt/Assets</th>
<th>Return on Assets</th>
<th>Sales/Assets</th>
<th>Log of Sales Growth</th>
<th>DE Incorp.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control Group Companies</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(# of companies = 699)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.255</td>
<td>6.553</td>
<td>0.248</td>
<td>0.027</td>
<td>0.254</td>
<td>-2.200</td>
<td>0.56</td>
</tr>
<tr>
<td>Median</td>
<td>1.161</td>
<td>6.620</td>
<td>0.238</td>
<td>0.028</td>
<td>0.231</td>
<td>-2.136</td>
<td>1.00</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.541</td>
<td>2.209</td>
<td>0.193</td>
<td>0.037</td>
<td>0.158</td>
<td>1.521</td>
<td>0.50</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.005</td>
<td>0.892</td>
<td>0.000</td>
<td>-1.045</td>
<td>-0.134</td>
<td>-17.775</td>
<td>0.00</td>
</tr>
<tr>
<td>Maximum</td>
<td>2.999</td>
<td>12.612</td>
<td>1.830</td>
<td>0.937</td>
<td>1.498</td>
<td>11.324</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>Treated Group (Carbon-intensive) Companies</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(# of companies = 690)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.736</td>
<td>6.766</td>
<td>0.191</td>
<td>0.012</td>
<td>0.202</td>
<td>-2.579</td>
<td>0.36</td>
</tr>
<tr>
<td>Median</td>
<td>0.494</td>
<td>6.815</td>
<td>0.139</td>
<td>0.006</td>
<td>0.019</td>
<td>-2.550</td>
<td>0.00</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.580</td>
<td>2.034</td>
<td>0.190</td>
<td>0.026</td>
<td>0.658</td>
<td>1.501</td>
<td>0.48</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.002</td>
<td>-1.546</td>
<td>0.000</td>
<td>-0.555</td>
<td>-0.104</td>
<td>-19.033</td>
<td>0.00</td>
</tr>
<tr>
<td>Maximum</td>
<td>2.984</td>
<td>15.008</td>
<td>2.663</td>
<td>0.215</td>
<td>42.218</td>
<td>7.350</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>Full Sample</strong></td>
<td></td>
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</tr>
<tr>
<td>(# of companies = 1389)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.997</td>
<td>6.659</td>
<td>0.219</td>
<td>0.019</td>
<td>0.228</td>
<td>-2.388</td>
<td>0.46</td>
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<tr>
<td>Median</td>
<td>0.934</td>
<td>6.748</td>
<td>0.177</td>
<td>0.018</td>
<td>0.166</td>
<td>-2.324</td>
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<td>Standard Deviation</td>
<td>0.618</td>
<td>2.127</td>
<td>0.194</td>
<td>0.033</td>
<td>0.478</td>
<td>1.522</td>
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<td>Minimum</td>
<td>0.002</td>
<td>-1.546</td>
<td>0.000</td>
<td>-1.045</td>
<td>-0.134</td>
<td>-19.033</td>
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<td>Maximum</td>
<td>2.999</td>
<td>15.008</td>
<td>2.663</td>
<td>0.937</td>
<td>42.218</td>
<td>11.324</td>
<td>1.00</td>
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Table 7.8: Covariate Correlations for Companies from Q4 2006 to Q3 2010

Notes: This table represents correlations for the Full sample. The covariates represent company-level data. Tobin’s Q is calculated at quarter end as the sum of common stock, debt and preferred stock, divided by the sum of property, plant and equipment, inventories, cash and short term investments and receivables.

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<th>Covariates</th>
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<th>(2)</th>
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<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
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<td>(1) Tobin’s Q</td>
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<td>(2) Log of Total Assets</td>
<td>-0.055</td>
<td>1.000</td>
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</tr>
<tr>
<td>(3) Debt/Assets</td>
<td>0.257</td>
<td>0.223</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(4) Return on Assets</td>
<td>0.249</td>
<td>0.124</td>
<td>0.107</td>
<td>1.000</td>
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<td></td>
<td></td>
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<tr>
<td>(5) Sales/Assets</td>
<td>0.145</td>
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<td>0.041</td>
<td>0.082</td>
<td>1.000</td>
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<tr>
<td>(6) Log of Sales Growth</td>
<td>0.143</td>
<td>-0.057</td>
<td>0.022</td>
<td>0.016</td>
<td>0.071</td>
<td>1.000</td>
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<tr>
<td>(7) DE Incorporation</td>
<td>0.242</td>
<td>0.027</td>
<td>0.179</td>
<td>0.100</td>
<td>0.123</td>
<td>0.101</td>
<td>1.000</td>
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</table>
Table 7.9: Log-Linear Specifications of Tobin’s Q using Ordinary Least Squares

Notes: All data is from Compustat, and represents American companies from Q4 2006 to Q3 2010. The dependent variable is company value as measured by the natural log of Tobin’s Q. Tobin’s Q is calculated at quarter end as the sum of common stock, debt and preferred stock, divided by the sum of property, plant and equipment, inventories, cash and short term investments and receivables. The results in this table are from estimation of equation (4.2) shown below:

\[
q_{ist} = \beta_0 + \beta_1 P_t + \beta_2 T_s + \beta_3 (T_s \cdot P_t) + \beta_4 (\theta_t \cdot T_s \cdot P_t) + \beta_5 \theta_t + \beta_6 (T_s \cdot P_t \cdot L_t) \\
+ \sum_{i=1}^{N} \sum_{t=1}^{T} \theta_{it} X_{it} + \sum_{s=1}^{S} \mu_s D_s + \sum_{t=1}^{T} \mu_t D_t + \epsilon_{ist}
\]

In this table: ** Statistically significant at the 10% level; ** Statistically significant at the 5% level; *** Statistically significant at the 1% level

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</thead>
<tbody>
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<td>Recession depth during legislative threat ((\theta_t \cdot T_s \cdot P_t))</td>
<td>-1.045*** (0.15)</td>
<td>-1.037*** (0.15)</td>
<td>-0.754*** (0.20)</td>
<td>-0.745*** (0.20)</td>
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<tr>
<td>Treated company in post period ((T_s \cdot P_t))</td>
<td>-0.259*** (0.02)</td>
<td>-0.259*** (0.02)</td>
<td>-0.218*** (0.03)</td>
<td>-0.217*** (0.03)</td>
<td></td>
</tr>
<tr>
<td>Post-threat period ((P_t))</td>
<td>-0.284*** (0.02)</td>
<td>-0.286*** (0.02)</td>
<td>-0.184*** (0.01)</td>
<td>-0.184*** (0.01)</td>
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</tr>
<tr>
<td>Treated ((T_s))</td>
<td>0.581*** (0.04)</td>
<td>0.572*** (0.05)</td>
<td>0.581*** (0.04)</td>
<td>0.572*** (0.05)</td>
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</tr>
<tr>
<td>Cumulative difference from peak GDP ((\theta_t))</td>
<td>-0.052 (0.11)</td>
<td>-0.056 (0.11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quarters since threat ((L_t))</td>
<td>0.008 (0.01)</td>
<td>0.009 (0.01)</td>
<td>0.015** (0.01)</td>
<td>0.016** (0.01)</td>
<td></td>
</tr>
<tr>
<td>Log of Total Assets</td>
<td>-0.035*** (0.01)</td>
<td>-0.030*** (0.01)</td>
<td>-0.030*** (0.01)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Debt/Assets</td>
<td>1.001*** (0.06)</td>
<td>1.023*** (0.06)</td>
<td>1.010*** (0.06)</td>
<td>1.030*** (0.06)</td>
<td></td>
</tr>
<tr>
<td>Lagged Operating Income/Assets</td>
<td>3.226*** (0.56)</td>
<td>3.345*** (0.53)</td>
<td>3.255*** (0.56)</td>
<td>3.376*** (0.54)</td>
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</tr>
<tr>
<td>Sales/Assets</td>
<td>0.163 (0.12)</td>
<td>0.153 (0.12)</td>
<td>0.165 (0.12)</td>
<td>0.155 (0.12)</td>
<td></td>
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<tr>
<td>Log of Sales growth</td>
<td>0.022*** (0.01)</td>
<td>0.020*** (0.01)</td>
<td>0.019*** (0.01)</td>
<td>0.016** (0.01)</td>
<td></td>
</tr>
<tr>
<td>1 if incorporated in Delaware</td>
<td>0.217*** (0.04)</td>
<td>0.205*** (0.05)</td>
<td>0.217*** (0.04)</td>
<td>0.205*** (0.05)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
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<td>-0.688*** (0.13)</td>
<td>-1.223*** (0.15)</td>
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<td>N</td>
<td>Y</td>
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<td>Quarter effects</td>
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Table 7.10: Log-Linear Specifications of Tobin’s Q using Generalized Least Squares

Notes: All data is from Compustat, and represents American companies from Q4 2006 to Q3 2010. The dependent variable is company value as measured by the natural log of Tobin’s Q. Tobin’s Q is calculated at quarter end as the sum of common stock, debt and preferred stock, divided by the sum of property, plant and equipment, inventories, cash and short term investments and receivables. The results in this table are from estimation of equation (4.2) shown below:

\[ q_{ist} = \beta_0 + \beta_1 P_t + \beta_2 T_s + \beta_3 (T_s \cdot P_t) + \beta_4 (\theta_t \cdot T_s \cdot P_t) + \beta_5 T_s + \beta_6 (T_s \cdot P_t \cdot L_t) \]

\[ + \sum_{i=1}^{N} \sum_{t=1}^{T} \theta_{it} X_{it} + \sum_{s=1}^{S} \mu_s D_s + \sum_{t=1}^{T} \mu_t D_t + \epsilon_{ist} \]

In this table: ** Statistically significant at the 10% level; ** Statistically significant at the 5% level; *** Statistically significant at the 1% level

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</thead>
<tbody>
<tr>
<td>Recession depth during legislative threat (( \theta_t \cdot T_s \cdot P_t ))</td>
<td>- 1.045***</td>
<td>-1.037***</td>
<td>-0.754*</td>
<td>-0.745**</td>
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<tr>
<td></td>
<td>(0.29)</td>
<td>(0.28)</td>
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<tr>
<td>Treated company in post period (( T_s \cdot P_t ))</td>
<td>- 0.259***</td>
<td>-0.259***</td>
<td>-0.218***</td>
<td>-0.217***</td>
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<tr>
<td></td>
<td>(0.04)</td>
<td>(0.04)</td>
<td>(0.05)</td>
<td>(0.05)</td>
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</tr>
<tr>
<td>Post-threat period (( P_t ))</td>
<td>- 0.284***</td>
<td>-0.286***</td>
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<td>-0.440***</td>
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<td>(0.02)</td>
<td>(0.02)</td>
<td>(0.02)</td>
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</tr>
<tr>
<td>Treated (( T_s ))</td>
<td>0.581***</td>
<td>0.572***</td>
<td>0.581***</td>
<td>0.572***</td>
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<tr>
<td></td>
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</tr>
<tr>
<td>Cumulative difference from peak GDP (( \theta_t ))</td>
<td>- 0.052</td>
<td>-0.056</td>
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<td>(0.09)</td>
<td>(0.09)</td>
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<td></td>
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<tr>
<td>Quarters since threat (( L_t ))</td>
<td>+ 0.008</td>
<td>0.009</td>
<td>0.015</td>
<td>0.016</td>
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<tr>
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<td>-0.030***</td>
<td>-0.038***</td>
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<tr>
<td>Debt/Assets</td>
<td>+ 1.001***</td>
<td>1.022***</td>
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<td>Lagged Operating Income/Assets</td>
<td>+ 3.226***</td>
<td>3.345***</td>
<td>3.255***</td>
<td>3.376***</td>
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<td>(0.12)</td>
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</tr>
<tr>
<td>Sales/Assets</td>
<td>+ 0.163***</td>
<td>0.153***</td>
<td>0.165***</td>
<td>0.155***</td>
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<td>(0.01)</td>
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</tr>
<tr>
<td>Log of Sales growth</td>
<td>+ 0.022***</td>
<td>0.020***</td>
<td>0.019***</td>
<td>0.016***</td>
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<tr>
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</tr>
<tr>
<td>1 if incorporated in Delaware</td>
<td>+ 0.217***</td>
<td>0.205***</td>
<td>0.217***</td>
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<td>Quarter effects</td>
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<td>N</td>
<td>Y</td>
<td>Y</td>
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Table 7.11: Log-Linear Specifications of Tobin’s Q using Ordinary Least Squares
And Power Plants in the Regional Greenhouse Gas Initiative States as the Control Group

Notes: All data is from Compustat, and represents American companies from Q4 2006 to Q3 2010. The dependent variable is company value as measured by the natural log of Tobin’s Q. Tobin’s Q is calculated at quarter end as the sum of common stock, debt and preferred stock, divided by the sum of property, plant and equipment, inventories, cash and short term investments and receivables. The results in this table are from estimation of equation (4.2) shown below:

\[ q_{ist} = \beta_0 + \beta_1 P_t + \beta_2 T_s + \beta_3 (T_s \cdot P_t) + \beta_4 (\theta_t \cdot T_s \cdot P_t) + \beta_5 \theta_t + \beta_6 (T_s \cdot P_t \cdot L_t) \]

\[ + \sum_{i=1}^N \sum_{t=1}^T \theta_{it} X_{it} + \sum_{s=1}^S \mu_s D_s + \sum_{t=1}^T \mu_t D_t + \epsilon_{ist} \]

In this table: ** Statistically significant at the 10% level; ** Statistically significant at the 5% level; *** Statistically significant at the 1% level

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<td></td>
<td></td>
<td>Sign</td>
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<tr>
<td>Recession depth during legislative threat ((\theta_t \cdot T_s \cdot P_t))</td>
<td>-</td>
<td>-2.211***</td>
<td>-2.235***</td>
<td>-1.018***</td>
<td>-1.017***</td>
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<td>(0.70)</td>
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<td>Treated company in post period ((T_s \cdot P_t))</td>
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<td>(0.05)</td>
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<td>1.347*</td>
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<td>(0.67)</td>
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<tr>
<td>Quarters since threat ((L_t))</td>
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<td>0.011*</td>
<td>0.000</td>
<td>-0.000</td>
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<td>(0.01)</td>
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<tr>
<td>Log of Assets</td>
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<td>0.019**</td>
<td>0.018**</td>
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<tr>
<td>Sales/Assets</td>
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<td>-0.171**</td>
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<td>(0.10)</td>
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<td>(0.10)</td>
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</tr>
<tr>
<td>1 if incorporated in Delaware</td>
<td>+</td>
<td>-0.026</td>
<td>-0.037</td>
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<td>(0.08)</td>
<td>(0.05)</td>
<td>(0.07)</td>
<td>(0.04)</td>
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<tr>
<td>State effects</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Quarter effects</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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</table>
Table 7.12: Log-Linear Specifications of Tobin’s Q using Ordinary Least Squares
Separating the Treatment Group into Two Groups: Good and Bad

Notes: All data is from Compustat, and represents American companies from Q4 2006 to Q3 2010. The dependent variable is company value as measured by the natural log of Tobin’s Q. Tobin’s Q is calculated at quarter end as the sum of common stock, debt and preferred stock, divided by the sum of property, plant and equipment, inventories, cash and short term investments and receivables. The results in this table are from estimation of equation (4.2) shown below:

\[ q_{ist} = \beta_0 + \beta_1 P_t + \beta_2 T_s + \beta_3 (T_s \cdot P_t) + \beta_4 (T_s \cdot P_t \cdot L_t) + \sum_{i=1}^{N} \sum_{t=1}^{T} \theta_{it} X_{it} + \sum_{s=1}^{S} \mu_s D_s + \sum_{t=1}^{T} \mu_t D_t + \epsilon_{ist} \]

In this table: ** Statistically significant at the 10% level; *** Statistically significant at the 5% level; **** Statistically significant at the 1% level

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<td>Recession depth during legislative threat - Bad</td>
<td>-1.072***</td>
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<td>(0.16)</td>
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<td>Recession depth during legislative threat - Good</td>
<td>-0.782***</td>
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<td>0.538***</td>
<td>0.554***</td>
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<td>(0.05)</td>
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<td>Cumulative difference from peak GDP</td>
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<td>Quarters since threat - Bad</td>
<td>0.010*</td>
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<td>0.017***</td>
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<tr>
<td>Quarters since threat - Good</td>
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<td>Constant</td>
<td>-0.435***</td>
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Chapter 7. Tables and Figures

Table 7.13: Log-Linear Specifications of Tobin’s Q using Ordinary Least Squares
Separating the Treatment Group into Two Groups: Good and Bad
Only Power Plants in the Sample

Notes: All data is from Compustat, and represents American companies from Q4 2006 to Q3 2010. The dependent variable is company value as measured by the natural log of Tobin’s Q. Tobin’s Q is calculated at quarter end as the sum of common stock, debt and preferred stock, divided by the sum of property, plant and equipment, inventories, cash and short term investments and receivables. The results in this table are from estimation of equation (4.2) shown below:

\[
q_{ist} = \beta_0 + \beta_1 P_t + \beta_2 T_s + \beta_3 (T_s \cdot P_t) + \beta_4 (\theta_t \cdot T_s \cdot P_t) + \beta_5 \theta_t + \beta_6 (T_s \cdot P_t \cdot L_t) + \sum_{s=1}^{S} \mu_s D_s + \sum_{t=1}^{T} \mu_t D_t + \epsilon_{ist}
\]

In this table: ** Statistically significant at the 10% level; ** Statistically significant at the 5% level; *** Statistically significant at the 1% level

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<td>Recession depth during legislative threat - Good</td>
<td>0.211</td>
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<td>0.141</td>
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