The Influence of Special Interest Groups on the Design of Environmental Regulation

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The Influence of Special Interest Groups on the Design of Environmental Regulation

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(Dr. sc. ETH Zürich)

presented by

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Joschka Gerigk
Abbreviations

BACT best available control technology
BAT best available technology
BTA border tax adjustment
CETA Comprehensive Economic and Trade Agreement
CO₂ carbon dioxide
EEA European Environment Agency
EEG Gesetz für den Ausbau erneuerbarer Energien
EII energy-intensive industry
ERF emission reduction fund
ETS emissions trading system/scheme
EUA EU Emission Allowance
GHG greenhouse gas
NEFCO Nordic Environment Finance Corporation
NFFO Non-Fossil Fuel Obligation
NGO nongovernmental organization
NorCap Norwegian Carbon Procurement Facility
NOₓ nitrogen oxides
OECD Organisation for Economic Co-operation and Development
PM particulate matter
REACH Registration, Evaluation, Authorisation, and Restriction of Chemicals (Regulation (EC) No 1907/2006)
RES (German) Renewable Energy Sources Act (see EEG)
RGGI Regional Greenhouse Gas Initiative
RoHS Restriction of Hazardous Substances (Directive 2002/95/EC)
SOₓ sulfur oxides
TPP Trans-Pacific Partnership
TTIP Transatlantic Trade and Investment Partnership
UNEP United Nations Environment Programme
VOC volatile organic compound
Zusammenfassung


Im zweiten Kapitel untersuchen wir gegenwärtige Anwendungsformen von sog. ‘command-and-control’ Regulierung, also von Politikinstrumenten, die vor allem auf (allgemeingültigen) Vorschriften und Grenzwerten basieren. Insbesondere betrachten wir Umweltstandards deren Grenzwerte durch ‘benchmarking’ bestimmt werden, d.h. durch den Vergleich der regulierten Akteure untereinander. Während die ökonomische Literatur traditionell marktbasierte Regulierungsinstrumente bevorzugt, können wir zeigen, dass heutige, differenzierte Anwendungsformen von Umweltstandards wirkungsvoll und unter bestimmten Bedingungen sogar effizient sein können.
Zusammenfassung

Darüber hinaus weisen wir nach, dass der Einfluss politischer Interessensgruppen auf derart Regulierung in den Fällen wohlfahrtssteigernd sein kann, in denen ‘benchmarking’ gar zu wirkungsvoll ist, d.h. wenn mehr Emissionsminderungen bewirkt werden als es ökonomisch opportun wäre.


Ein politökonomisches Wettbewerbsmodell kommt auch im vierten Kapitel zur Anwendung, um die unvollständige Durchsetzbarkeit einer Emissionssteuer zu untersuchen. Grundlage der Analyse ist die Annahme, dass politische Interessensgruppen die unvollständige Durchsetzbarkeit einer sich im Gesetzgebungsprozess befindlichen Umweltsteuer antizipieren und dementsprechend ihre Bemühungen diese zu verhin dern bzw. umzusetzen daran anpassen. Bei der Festlegung ihrer Lobbyingaktivitäten berücksichtigen die Interessensgruppen also nicht nur die vorgeschlagene Höhe der Emissionssteuer, sondern auch die (voraussichtliche) Durchsetzbarkeit, die sowohl von den Kontrollbemühungen als auch von der Höhe potentieller Strafen abhängig
ist. Mit Hilfe häufig verwendeter funktionaler Spezifikationen ist es mir möglich zu zeigen, dass die unvollständige Durchsetzbarkeit einer Steuer den erwarteten Nutzen eines Politikvorschlags für die Umwelt sogar erhöhen kann, da so die Bemühungen der Industrie die Regulierung zu verhindern deutlich reduziert werden.

Abstract

This thesis investigates the important role special interest groups play in the design of environmental regulation and analyzes some of the drivers of their political efforts. The three main chapters present a set of closely related, but self-contained papers that mainly draw from concepts in game and contest theory. More specifically, the theoretical economic analyses of the three papers build on the contest approach outlined in Tullock (1980), a framework I use to model the competition between special interest groups. It is argued that the role of the latter may have been insufficiently accounted for in much of the earlier literature on environmental regulation.

In Chapter 2, we analyze modern forms of ‘command-and-control’ regulation, in particular, environmental standards stipulated via benchmarking. Whereas the conventional economic argument favors the use of market-based instruments, we show that contemporary forms of command-and-control regulation have the potential to be both effective and, under certain conditions, even efficient. When, from an economic perspective, environmental standards based on performance benchmarks provide excessively strong incentives to abate pollution, lobbying by special interest groups may be able to improve regulatory performance.

Chapter 3 studies the influence of special interest groups on environmental regulation in an open economy. This study aims at explaining the occurrence of policy diffusion, by which we mean a country’s adoption of environmental policies similar to the stricter regulation of its trading partners. In our contest framework, two lobby
groups, which represent industrial and environmental special interests, respectively, compete over influence on the legislator’s policy decision. The groups’ lobbying efforts are not only dependent on the domestic policy proposal but also on environmental regulation abroad. After developing a general framework with perfect competition to identify conditions under which a country may unilaterally adopt stricter regulatory standards, we employ common functional forms to specify our model and are able to demonstrate that both market structure and the vulnerability to pollution are crucial determinants of the political equilibrium.

In Chapter 4, I analyze incomplete enforcement in a political contest framework. In anticipation of the imperfect enforceability of a proposed emission tax, special interest groups change their lobbying behavior in their support of or opposition to the policy proposal. I am able to demonstrate that both the level of the proposed tax as well as its enforceability, which depends on monitoring effort and potential fines, are important drivers of the lobbies’ efforts. Applying ordinary functional specifications, I show that incomplete enforcement may—by reducing the industry’s opposition compared to the case of full enforceability—actually improve the expected environmental benefit of the proposed policy.

The main contribution of this thesis is to highlight the important role special interest groups may have in the legislative process and that—by accounting for their influence—widely accepted views on the efficiency and effectiveness of prevalent regulatory instruments may have to be scrutinized. The research presented here enhances the understanding of the drivers and impact of lobbying by special interest groups in three important settings and adds to the growing literature on the political economy of environmental regulation.
Chapter 1

Introduction

Well-functioning public institutions are the pillars of the market economy. Adam Smith, seen by many as one of the founding fathers of economics, emphasized in his seminal work that governments typically have to intervene when markets fail to provide what “may be in the highest degree advantageous to a great society” (Smith, 1776, p. 677). Smith’s vision of government centered around the following core functions: state defense, public education, the provision of infrastructure, and a judicial system able and willing to protect private property. It is well established though that the use of private property as a factor of production (i.e., capital) may inflict harm on others and, in turn, reduce the opportunity of the victims to use their own factors of production, for example, capital or labor, in the most productive and socially beneficial way.

In his pioneering paper in 1960, Ronald H. Coase showed, however, that—under certain conditions—the market may be able to overcome such external effects as long as property rights are transferable and assigned unambiguously (Coase, 1960): given the reciprocal nature of externalities, without transaction costs, he argued, resources would always be used in the most productive way, regardless of their initial allocation. He applied this insight to the potential health and environmental impacts of
production, in particular, and concluded: whether a polluting firm was granted the right to pollute or the victim of pollution was granted the right to be unharmed, the two would always negotiate and agree on the socially optimal degree of production (and harm). Coase himself emphasized, however, that negotiations are often sufficiently costly to prevent many transactions and that “[i]n these conditions the initial delimitation of legal rights does have an effect on the efficiency with which the economic system operates” (Coase, 1960, p. 16). It is this distributive effect and the fact that transaction costs are particularly high for many pollutants—given the small marginal impact of individual sources, various intangible effects, and the potentially great number of victims—that makes environmental regulation prone to the influence of political lobbying, the subject of this thesis. As a result, the regulation of pollution is typically not set by a benevolent policymaker at the welfare-maximizing level, but it is rather the outcome of political competition between the affected actors. In what follows, we assume that these actors form special interest groups to represent their concerns and to sway regulation in their favor.\(^1\) In doing so, we seek to assist in the understanding of the political game that often drives environmental regulation and of the motives that underlie the actions of the players (i.e., stakeholders) involved. Given the important role played by interest groups in the legislative process in most modern democracies, this research tackles very salient issues and is highly policy relevant.

By extending the analysis of special interest groups’ influence on different policy instruments, the studies presented here contribute to the literature on the political economy of environmental regulation. The remainder of this chapter lays out the motivation for studying this topic by discussing its practical relevance, briefly reviews some of the earlier work on environmental regulation and introduces the main method used before outlining the research questions as well as the structure of the thesis.

\(^1\)Here, the term ‘(special) interest groups’—used interchangeably with ‘lobbies’ or ‘lobby groups’—simply refers to the contestants for the rents associated with regulation. The question how and under which circumstances the collective action problem is overcome for special interest groups to form is beyond the scope of this thesis and the interested reader is referred to Olson (1965).
1.1 Relevance and motivation

During recent decades, unprecedented economic growth has helped to improve the lives of billions of people, yet at the same time, this growth has been accompanied by equally unprecedented pollution that has exacted a tremendous toll on the environment (UNEP, 2012a). Although, particularly in developed countries, some progress has been made in curbing environmental pressures, at a global level, resource use and the emission of pollutants—such as effluents, greenhouse gases (GHG), sulfur oxides (SO$_X$), or nitrogen oxides (NO$_X$)—have continued to rise (Arto et al., 2012). These pollutants are emitted by a variety of sources, including agricultural production, domestic consumption and heating, transport, and, importantly, industrial processes. In the following chapters, the focus will be on the latter, which is justified by industry’s vast share of total emissions: for example, it is estimated that in Europe in 2012, industrial processes accounted for 85% of SO$_2$ emissions, 50% of GHG emissions, 40% of NO$_X$ emissions, as well as 20% of emissions of fine particulate matter (PM2.5) and non-methane volatile organic compounds (VOCs) (EEA, 2015, p. 104). The consequences are manifold: emissions from industrial production and the ensuing environmental impact may threaten biodiversity, reduce agricultural yield, contribute to climate change, cause a variety of (respiratory) diseases accountable for millions of deaths per year, and, as a result of all this, they may be responsible for very sizable economic losses (e.g., Stern, 2007; OECD, 2012). Action to reduce the adverse impact of pollution by regulating emissions is, therefore, not only a moral imperative but also an economic one.

When drafting such regulation, the policymaker naturally faces the challenge of deciding on its required level (i.e., its stringency), which is a very demanding assignment without an understanding of the maximal amount of pollution the earth’s atmosphere is able to absorb. While the latter question has to be addressed by natural scientists, it is the task of the social sciences—and economics in particular—to find the
appropriate policy instruments to ensure that pollution does not exceed this limit and to balance the economic costs and the benefits to the environment. Economists have embraced this challenge and put forward a considerable variety of policy instruments to regulate environmental externalities. The key distinction typically made in the literature is that between so-called ‘command-and-control’ regulation and market-based instruments (e.g., Kolstad, 2009). Whereas the former includes, inter alia, universal emission restrictions or input bans and may prescribe specific abatement actions that the polluter has to implement, the latter may come in the form of taxes (including subsidies), marketable permits, but also liability rules. To varying degrees, all of these instruments—and some hybrid versions—are used today in order to limit pollution.²

A common feature of all regulatory instruments is their impact on both the earning potential of polluters—e.g., through affecting their competitiveness—and the degree of harm incurred by the victims of pollution. As a result, regardless of the instrument at work, in making regulatory choices, the legislator is often influenced by the affected stakeholders and models of environmental regulation that do not account for this influence are limited in their potential to explain actual policies. With a focus on the motives behind interest groups’ lobbying, this thesis is an attempt to shed more light on this important aspect of reality.³ While interest groups may be able to alter regulation at the earliest possible stage, that is, they may be able to impact a policy proposal even before it is presented to the legislator, our focus is mostly on their impact on the legislative process itself. In other words, instead of studying the lobbying of regulators, we consider the lobbying of the legislator and analyze how the likelihood of policy approval—and its consequent implementation—is affected by interest groups’ influence once a proposal has been submitted to parliament.

²The OECD’s ‘Database on instruments used for environmental policy’ provides a comprehensive overview of their use (see OECD, 2016).
³It is straightforward to identify opposing interests when it comes to, for example, speed limits or the ban of night-time flights to reduce noise pollution; restrictions on industrial production or car use in cities to limit air pollution; grandfathering of emission permits; or the introduction of energy taxes.
1.1 Relevance and motivation

In doing so, we consider three specific regulatory environments. The objective of this thesis is to add to the literature by filling gaps in the understanding of political influence in these distinct settings that have not been assessed by previous studies. First, we consider benchmarking as a tool to enhance the efficacy of environmental standards. To date, command-and-control regulation has been the dominant form of environmental policy (see Kolstad, 2009) and benchmarking has been suggested by policymakers as a measure to improve its efficiency (see Ackermann et al., 1999). In Chapter 2, we aim to scrutinize this suggestion by providing a theoretical model of environmental standards stipulated via benchmarking, which we show to be potentially much more efficient and effective than the ordinary command-and-control instruments that are typically portrayed in the economics literature. At the same time, we highlight why and how interest groups may seek to influence such regulation. The third chapter tries to reconcile the fact that countries frequently adopt the stringent environmental policies of their trading partners—referred to as ‘policy diffusion’—with the predictions of economic theory, which suggest that to maintain competitiveness or obtain an advantage, freely trading countries tend to relax regulation rather than tighten it. The previous literature on this topic is mostly in the field of political science and has yet to provide a rigorous, formal analysis of the potential role of lobbying as determinant of policy diffusion, a void we seek to fill. Deviating from the traditional political economy literature, Chapter 4 introduces incomplete enforcement into the analysis of political competition. Clearly, regulated firms have both an incentive and often the opportunity to sidestep existing legislation, which may affect the lobbying incentives of both opponents and supporters of regulation. Focusing on the impact of enforceability on the lobbying incentives of special interest groups, we provide one of the first analyses endogenizing incomplete enforcement in a political contest

4 ‘Benchmarking’ is not uniquely defined and may refer to relative performance mechanisms generally. The latter assess the performance of a regulated firm relative to a predefined group of competitors. Here, benchmarking is mostly used as synonym for the comparison of a firm’s performance to the average performance of the regulated industry.
framework and show that, contrary to conventional wisdom, imperfect enforceability may have environmental benefits. The following Section 1.2 briefly summarizes the relevant literature on different policy instruments and the political economy of environmental regulation that underlies our analyses.

1.2 Theoretical background and method

As Agnar Sandmo points out in his review of the history of environmental economics, it was Nicolas de Condorcet in 1776 who pioneered the idea that one person’s exercise of her private property rights could interfere with the rights of others—i.e., that individual choices could exert externalities—and that this may necessitate government intervention (Sandmo, 2015, p. 44). According to Sandmo, the only kind of policy considered at the time was an outright ban of the harmful activity—if the detriment was considerable enough—and it was not until the works of Arthur C. Pigou that more refined policy choices, in particular taxes, were considered and formalized: Pigou (1920) distinguished between social and private marginal cost and argued that the imposition of an appropriate tax (subsidy) could align the two where they diverge in order to limit (expand) production to the socially optimal level. This was the first mention of a market-based instrument to internalize environmental externalities. Whereas Pigou also considered bans (i.e., command-and-control regulation) as a means to reduce adverse external effects, he did not ponder the possibility of using tradable permits, the other classical market-based instrument. The latter is founded on the seminal idea of Coase (1960), who suggested harnessing the potential of markets to provide an efficient distribution of transferable property rights. The question of which policies should be implemented to reduce pollution is regarded as normative—its answer typically requires judgments based on subjective goals (e.g., internalizing externalities at least cost)—and much of the early environmental economics literature focused on developing normative theories of regulation (e.g., Baumol and Oates, 1971; Weitzman,
1.2 Theoretical background and method

1974; Goulder and Parry, 2008). It is well established in these works that market-based instruments are typically more efficient than command-and-control policies in achieving a given environmental objective. Pigou, however, had already emphasized that, although important, focusing on the identification of optimal policy instruments may be misguided:

“[f]or we cannot expect that any public authority will attain, or will even whole-heartedly seek, that ideal. Such authorities are liable alike to ignorance, to sectional pressures and to personal corruption by private interest.” (Pigou, 1920, p. 332)

The aforesaid sectional pressures and private interests are at the core of the analyses presented in this thesis and of the positive theories of (environmental) policy that started with Buchanan (1962), which seek to explain observed phenomena rather than identifying and characterizing desirable outcomes. The relative inefficiency of much of the existing regulation, as opposed to the instruments proposed by the normative works mentioned above, led to the development of a variety of models attempting to describe the actual determination of regulation within a political economy framework. Recent contributions to the literature discuss the extent and significance of this political influence in the context of both market-based policies (e.g., Joskow and Schmalensee, 1998; OECD, 2006; Anger et al., 2015) as well as command-and-control regulation (e.g., Lévéque, 1996; Coen, 1998). Unlike normative studies, these models no longer assumed the legislator to be benevolent and solely maximizing the welfare of society as a whole, but they acknowledged the legislator’s potentially conflicting (private) interests and the role of special interest groups. A common result of such studies was to demonstrate that some widely accepted conclusions of the literature on optimal instrument choice were no longer valid. Important early contributions were made by Buchanan and Tullock (1975) and Dewees (1983), who analyzed the

Oates (2001) summarizes the early literature on the political economy of environmental policy.
impact of various regulatory instruments on different interest groups and were able to rationalize, for example, why firms and regulators alike may prefer command-and-control regulation over effluent taxes despite the relative inefficiency of direct control instruments.

More recently, positive analyses of environmental policy have attempted to not only examine the impact of regulation on different interest groups but to also predict the outcome of the political competition among them. Two main approaches have dominated the analysis of lobby group interaction and the ensuing environmental policy outcomes in the last two decades. The first—referred to as ‘common-agency model’—employs the framework of Grossman and Helpman (1994), who adopted the menu auction of Bernheim and Whinston (1986) to analyze trade policy. This model has found numerous applications in environmental policy, including the works of Aidt (1998); Fredriksson (1999); Fredriksson and Sterner (2005); Habla and Winkler (2013), and Anger et al. (2015). It considers an incumbent government that, depending on regulatory stringency, is offered political support from various lobby groups. The government then chooses the policy level that maximizes its likelihood of re-election, which requires a well-defined objective function and predetermined weights that the government puts on social welfare and contributions from lobbies, respectively. The latter is in contrast to the second commonly used approach, which is often referred to as (public-)policy contest model. This framework builds on the theory of contests and studies the probability—determined by a contest success function—of a given policy proposal being implemented (e.g., Epstein and Nitzan, 2010). A nonrepresentative list of papers on environmental regulation that are based on this approach includes Baik and Shogren (1994); Heyes (1997); Dijkstra (1998), and MacKenzie and Ohndorf (2012a). Whereas the common-agency framework is more suitable to investigate the endogenous determination of policy stringency, our focus is on the competition between the interest groups, which the contest model is better able to capture and ana-
1.2 Theoretical background and method

lyze. The rest of this thesis, therefore, follows the policy contest framework. We model the political process and the interaction between special interest groups as a contest in which the contest success function, which determines the probability of a given lobby to win the political competition, plays a crucial role. While other specifications are possible, just like the above-mentioned papers, we focus on the generalized lottery (or logit) function proposed by Tullock (1980). The main assumptions and determinants of this variant of the policy contest model are summarized in the next subsection.

The political contest framework

In their description of political competition and actual policy determination, contest models, of course, have to abstract from a number of factors observed in the real world and rely on simplifying assumptions that allow the analysis to isolate and identify economic cause and effect of the characteristics at issue. As such, contest models typically consider a legislator’s binary choice between two policy alternatives. Following a common approach in the literature, the studies that form the principal part of this thesis, Chapters 2-4, are largely restricted to the influence of two special interest groups, $i$ and $j$, and assume that one of the policy alternatives is the continuance of the status quo. The legislator’s binary choice is then reduced to either approval or rejection of just one policy proposal, which the analysis centers on. The basic structure of the game can be summarized as follows:

1. Environmental regulation is proposed to the legislator by the government (or a government-employed bureaucrat or regulator) at some level $R$.

---

6The literature also commonly uses an all-pay auction to specify the contest success function. This, however, implies that the interest group that expends the most effort always wins and its preferred policy is implemented at any rate, which seems to attribute an overly strong influence to any one lobby.

7This subsection draws heavily from the disquisition on contests in Konrad (2009) and Epstein and Nitzan (2010).

8$R$ could, for example, symbolize the level of an emission tax or the efficacy of a filter prescribed by command-and-control regulation. The exact determination of $R$ can be modeled explicitly and could be an optimization problem in itself; however, for the most part, we consider an unspecified level $R$ and derive more general results applying to any level of policy stringency.
2. Interest groups $i$ and $j$ gauge the impact of $R$ on their respective objectives and simultaneously decide on the extent of their lobbying efforts to influence the legislator’s decision.

3. The probability of policy approval by the legislator—defined by the contest success function—is determined by the lobbies’ respective efforts.

Without loss of generality, assume now that group $i$ prefers the approval of $R$, whereas group $j$ prefers its rejection, hence, $i$’s success in the political contest is equivalent to the approval of $R$ and results in a payoff of $\Omega_i$ for interest group $i$. $j$ values this outcome at $\Omega_j < \omega_j$, where $\omega_j$ is the value to $j$ of its preferred outcome, namely, the rejection of the policy proposal. In that case, the payoff for interest group $i$ is denoted $\omega_i < \Omega_i$. The differences in payoffs between policy approval and policy rejection define the political stake of each player (the rent or avoided loss), which is denoted by $V_i = \Omega_i - \omega_i$ and $V_j = \omega_j - \Omega_j$, respectively.

Let $p_i$ ($p_j$) denote the probability of lobby $i$’s ($j$’s) preferred contest outcome—i.e., $p_i$ is $i$’s contest success function—and let $k_i$ ($k_j$) denote the effort level of lobby $i$ ($j$), which factors into the legislative decision. Interest group $i$ chooses the effort $k_i$ that maximizes its expected net payoff (group $j$’s optimization problem is analogous):

$$\max_{k_i} E[\pi_i] = p_i(k_i, k_j) \cdot \Omega_i + p_j(k_i, k_j) \cdot \omega_i - k_i.$$  \hspace{1cm} (1.1)

The following chapters mostly focus on the simple lottery contest success function such that lobby $i$’s probability of winning the political contest is given by the ratio between its own lobbying effort and the total lobbying outlays of both lobby groups:

$$p_i = \frac{k_i}{k_i + k_j}.$$  \hspace{1cm} (1.2)

---

9This is a frequently used special case of the generalized lottery contest success function. In the general form, variants of which we consider in all of the following three chapters, $i$’s probability of success is a function of the ratio between its own lobbying effort and the total lobbying outlays, i.e.,
1.2 Theoretical background and method

Using equations (1.1) and (1.2), it is straightforward to calculate \( i \)'s equilibrium effort level given by

\[ k_i^* = \frac{V_i^2 \cdot V_j}{(V_i + V_j)^2}. \]

Applying this finding to equation (1.2) establishes the well-known result that, in equilibrium, the probability of lobby group \( i \) winning the contest—i.e., the likelihood of policy approval—is given by the ratio between \( i \)'s political stake and the sum of \( i \)'s and \( j \)'s political stakes:

\[ p_i^* = \frac{V_i}{V_i + V_j}. \]  \hspace{1cm} (1.3)

In equilibrium, if the proposed regulation leads to the political stake of \( i \) being greater than that of \( j \) (i.e., if \( V_i > V_j \)), then the probability of policy approval, \( p_i^* \), is greater than the probability of its rejection. For instance, if an externality of \( j \) on \( i \) is abated at a low cost to \( j \), regulation may entail large benefits to \( i \) and, hence, a large political stake \( V_i \), whereas \( V_j \) would be comparatively small. Naturally, the stakes of the interest groups and, therefore, their effort levels as well as the probability of \( i \)'s success in the contest are functions of the specific attributes of the proposed policy \( R \). We point out and examine three settings in which the characteristics of actual policies and the evolution of their stringency contradict the predictions of conventional economic theories. Our objective is to adapt the policy contest framework in order to explain this divergence by identifying the drivers of the lobby groups’ efforts to sway regulation and by analyzing their interaction and influence on the political equilibrium in the three distinct settings. In doing so, similar to previous positive studies of environmental regulation, we show that some widely accepted findings regarding the stringency and characteristics of various policy instruments may have to be reconsidered. Section 1.3 outlines the three settings, the research questions, and the contribution of this thesis.

\[ p_i = \frac{k_i}{k_i + \gamma_j k_j}, \] where \( \gamma_j \) symbolizes the potentially greater (or lesser) efficiency of the opposing group \( j \) in influencing the contest outcome—this could, e.g., be based on greater (more limited) access to the legislator or simply a bias by the latter—and \( r \) captures the returns on lobbying efforts.

\[ 10 \] This follows from \( \max_k E[\pi_i] = \frac{k_i}{k_i + \gamma_j k_j} \cdot \Omega_i + \frac{\gamma_j k_j}{k_i + \gamma_j k_j} \cdot \omega_i - k_i. \]
1.3 Structure of the thesis and contribution to research

As was pointed out in the previous section, the early environmental economics literature mostly dealt with the design of optimal policy instruments and the analysis of their relative efficiency in limiting emissions to a predefined target. This thesis is an attempt to assist in explaining why, ever since its introduction, environmental regulation has deviated considerably from theoretically optimal and efficient policies. In particular, we seek to identify the causes of political lobbying and its effect on environmental policies in equilibrium. The central theme of the analysis presented here is, therefore, to account for the political interaction between special interest groups and—in due consideration of their influence on the legislative process—to revisit some of the traditional arguments that rationalize the strategic considerations of the legislator and that favor one policy instrument over another. At the core of this thesis are three closely related and yet independent and self-contained papers (Chapters 2 to 4) followed by a concluding chapter (Chapter 5). Throughout the three separate papers, the political competition between interest groups is analyzed using the contest framework laid out above. The research questions and contributions of the individual chapters are introduced below.

Chapter 2: A Model of Benchmarking Regulation: Revisiting the Efficiency of Environmental Standards

As highlighted above, standard economic theory suggests that market-based instruments, which account for the differences in marginal abatement costs between polluters, are superior to command-and-control regulation, which typically prescribes the same controls to all emitters and, therefore, lacks dynamic incentives to improve environmental performance. Nevertheless, environmental standards have been the dominant form of environmental policy over the last few decades (Kolstad, 2009). Their prevalent application may be partly explained by the fact that the implementation of
such standards rather than market-based policies may be in the interest of not only the regulator but also of the regulatees: Buchanan and Tullock (1975) demonstrate how such policies, unlike emission taxes, may shield existing firms from the competition of new entrants. Given the consequent importance of environmental standards, the fundamental question arises, though, if and how one could improve their efficiency. To do so, policymakers have proposed a variety of measures, in particular benchmarking. It is argued that, by taking the relative performance of polluters into account, environmental standards stipulated via benchmarking could (partly) overcome the typical shortfalls of command-and-control regulation relating to its inefficiency in achieving a certain level of abatement. At the same time, by assigning market shares or limiting production according to a firm’s relative emission reduction, such implicit standards could have even stronger distributive effects than conventional command-and-control instruments. In addition, owing to its potential dynamic incentives, benchmarking regulation may stimulate more pollution abatement, hence, generating larger environmental benefits. Accordingly, the motivation of both supporters and opponents of such policies to manipulate the probability of their approval are amplified. The objective of Chapter 2 is, therefore, twofold: first, by devising a model of benchmarking in abatement, we reconsider the analysis of environmental standards with special attention to the most commonly expressed criticism regarding their static and dynamic inefficiencies. Second, we analyze the effect of benchmarking on the incentives of special interest groups to lobby and the ensuing impact on the efficacy of regulation. In short, the guiding questions of Chapter 2 are:

**Research question 1.A:** Can the inclusion of relative performance mechanisms in command-and-control regulation improve the effectiveness and efficiency of environmental standards?

**Research question 1.B:** How do special interest groups affect the efficiency of environmental standards stipulated via benchmarking?
To address these questions, we revisit the conventional economic argument favoring the use of market-based instruments over command-and-control regulation. This viewpoint is often limited in its conception of the latter; namely, environmental standards are often portrayed as lacking structured abatement incentives. Yet we find that contemporary forms of command-and-control regulation, such as standards stipulated via benchmarking, have the potential to be efficient. We provide the first formal analysis of environmental standards based on performance benchmarks and show that, under specific conditions, standards can provide efficient incentives to improve environmental performance. Finally, we demonstrate the welfare-enhancing effect of lobbying when the incentives of benchmarking regulation to abate pollution exceed the social optimum.

Chapter 3: Environmental Policy Diffusion, Lobbying, and Market Structure

An important factor in the determination of environmental policy as well as in establishing its impact on the polluters is the relative regulatory stringency between countries. Both the literature on trade and the environment as well as studies on environmental federalism have often argued that the competition between jurisdictions for mobile resources—in particular capital—could induce a so-called ‘race-to-the-bottom’ (among others, Wilson, 1996; Oates, 2001; Revesz, 2001; Rauscher, 2005). The simple logic that—when goods are traded freely and factors of production are mobile—the jurisdiction with the least stringent policy, hence, the lowest compliance cost, would attract the most capital and, therefore, competition would lead to low or even no controls on pollution seemed evident and yet is inconsistent with the observation that empirical studies have found no evidence of such a downward spiral. To the contrary, environmental regulation has become increasingly strict over time. While, among other factors, coercion and cooperation have been identified as potential drivers of this development and Porter and van der Linde (1995) even argued that stricter regulation
may afford regulatees a competitive advantage as it may increase their willingness to innovate, little attention has been paid to political factors. With reduced competitive pressure from already regulated producers abroad, however, polluters may be less opposed to the introduction of environmental policies at home. At the same time, if—as a consequence of previously lax regulation—the domestic industry supplies a large share of total demand, its stake in preventing future regulation may also be high. Environmental lobbies, on the other hand, may find a restriction on pollution particularly important in that case. Whether it is more or less likely under these circumstances for the stricter regulation of one country to spread to another, a process often referred to as ‘policy diffusion’, is, a priori, unclear. In trying to explain the occurrence of policy diffusion, we analyze the impact of foreign regulation on the lobbies’ objectives and efforts to support or oppose domestic regulation and we ask:

**Research question 2:** Under which circumstances can an environmental interest group successfully lobby for the diffusion of environmental policy and under which circumstances can an industrial lobby group prevent it?

We seek to address research question 2 by examining the regulation of pollution in an open economy when its legislator is influenced by special interest groups. Using a political contest framework, we aim to explain policy diffusion, namely, a country (partly) adopting the stricter environmental policies of its competitors. In our model, two lobby groups—representing industrial and environmental interests—seek to advocate or prevent the approval of domestic regulation. Their lobbying efforts not only depend on the proposed domestic policy but also on the level of foreign environmental regulation. We devise a general framework to identify conditions under which a country may unilaterally adopt stricter regulatory standards and—using common functional forms to specify our model—we show that both market structure and the characteristics of the pollutant are crucial in determining the potential for policy diffusion.
Chapter 4: Emission Taxes, Lobbying, and Incomplete Enforcement

The final substantive chapter of this thesis acknowledges the reality that the effectiveness of proposed environmental regulation and the ensuing incentives of the interest groups to oppose or support such a proposal crucially hinge on the enforceability of that regulation, a point widely neglected in previous political economy models of environmental policy. Enforceability—i.e., the ability of a regulatory authority to compel observance of legal restrictions—is typically a function of both the likelihood of the regulator to detect noncompliance and of the fines associated with violations. In a more general setting, this point was made by Gary Becker in his seminal analysis of the economics of crime, in which he argued that the more effort is expended to verify compliance with the law (as, e.g., shown by the number of policemen, judges, etc.) or the higher the potential penalty for offenders (monetary fine or length of imprisonment), the less likely it is for offenses to occur in the first place (Becker, 1968). Notwithstanding that numerous authors have adopted and extended Becker’s framework to study environmental policy and to analyze the effects of relaxing some of its key assumptions (e.g., Heyes, 1994; Nowell and Shogren, 1994; Livernois and McKenna, 1999; Nyborg and Telle, 2004; MacKenzie and Ohndorf, 2012b), the effect of the incomplete enforceability of regulation on the lobbying behavior of interest groups has received little attention. Nonetheless, this effect may be significant: the weaker the anticipated enforcement of a proposed policy, the lower the expected cost to noncompliant polluters, which could reduce both their opposition to the proposal as well as its expected environmental benefit, which in turn drives the support of environmental interest groups. The final research question this thesis addresses is, therefore:

**Research question 3:** What is the impact of a proposed policy’s incomplete enforceability on the strategic behavior of the interest groups and the probability of the proposal’s approval?
To answer this question, we adapt the policy contest model to explain changes in lobbying behavior when special interest groups anticipate the incomplete enforceability of an emission tax. After the tax is proposed, two lobby groups, which represent the interests of polluters and environmentalists, respectively, try to influence the legislator’s decision to approve or reject the implementation of the regulation. We develop a basic model to demonstrate that the efforts of the interest groups to sway the legislator are motivated not only by the stringency of the proposed policy—as determined by the level of the tax—but, importantly, also by the policy’s anticipated enforceability. Using common functional specifications, we then underline the potential benefits of incomplete enforcement, which may not only diminish the industry’s opposition to regulation compared to a situation with full enforcement, but it may—despite the possibility of misreporting of emissions—also reduce expected environmental damage.

Chapter 5: Conclusion

Finally, in Chapter 5, we highlight the main results of the papers presented here, summarize their contributions to the economics literature on environmental policy and also provide a brief outline of potential future research. This includes a discussion of how the political economy framework used in the analyses of this thesis may prove useful in future work. The chapter—and thesis—ends with a reflection on the practical relevance of the presented results and some policy recommendations.
2.1 Introduction

Since the writings of Pigou (1920) and Coase (1960), an important debate has centered around the control of externalities. Parallel to this debate has been the discussion of policy choice; namely, the use of market-based instruments versus ‘command-and-control’ regulation.\(^1\) Command-and-control regulation is typically criticized on two

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\(^1\)Despite significant advances in the use (and understanding) of market-based instruments over the last five decades, command-and-control regulation remains dominant. Explanations for instrument choice can be seen in, e.g., Buchanan and Tullock (1975), Oates et al. (1989), and Aidt and Dutta (2004).
important grounds: first, for not taking into account varying (marginal) abatement costs—thus not reducing pollution at least cost—and second, for not providing sufficient incentives to develop and adopt new technologies (e.g., Jaffe et al., 1995; Requate and Unold, 2003; Requate, 2005).²

The conventional argumentation in favor of market-based instruments, however, usually assumes command-and-control policies to be at their most restrictive. For example, when comparing cost effectiveness, the conventional comparison usually assumes command-and-control policies provide a uniform emissions limit on all firms. Yet modern approaches to environmental standards are more sophisticated, which is often not accounted for in policy comparisons. While the development of market-based instruments has received much attention, the same cannot be said for the innovative developments within command-and-control regulation, like introducing flexible emission standards that take differences in abatement cost into account.

Given most countries still heavily rely on command-and-control policies, standards stipulated via benchmarking have the potential to significantly increase the efficiency of environmental regulation. Nevertheless, while benchmarking regulation has been discussed in environmental policy for more than a decade, the formal modeling of the underlying incentives is sparse. With this article, we contribute to filling that void.

We construct a framework where the division of a rent is conditional on relative environmental performance. As an example, we consider the allocation of operating licenses to potential suppliers on a product market that depends on their adherence to an emission standard: a firm’s operating license determines the level of output it may provide (i.e., its market share), where the scope of the license (i.e., the admissible quantity produced) is larger for lower levels of absolute emissions. More precisely, the scope of firm $i$’s license is determined by its abatement effort relative to the emission

²A notable exception is Montero (2002), who finds that standards may offer greater R&D incentives than permits because R&D under standards only reduces a firm’s own cost, but not that of its rivals.
standard, which is defined by the industry’s average abatement level. Hence, a firm with relatively clean (polluting) production technology is allowed a larger (smaller) share in total production. In contrast to traditional emission standards, the constraint on emissions in this setup is flexible and incentive-based, which allows firms to both under- and over-pollute relative to the benchmark. Instead of losing their entire concession, heavy polluters are granted a license of smaller scope, whereas the license assigned to overperformers allows a larger scope of production and, hence, market share. To regulate firms, a variety of criteria can be used. For example, firms’ operating licenses could be based on emissions abatement efforts associated with switching between electricity sources (from, say, coal-produced to renewable sources). Thus firms that switch to a larger relative level of renewables are rewarded with an increased scope of the operating license. With cleaner firms serving larger shares of the market, of course, aggregate emissions decrease.

The important aspect of using the industry average as a benchmark is the induced competition in emission abatement. As a relative performance mechanism, benchmarking is thus very similar to yardstick competition (see Shleifer, 1985). In this chapter, we adapt the idea of basing regulation on average performance to an environmental context. In contrast to earlier work on yardstick competition where the regulator observes marginal production cost and sets a price, we allow the regulator to instead observe firms’ abatement and regulate polluting production. To analyze the incentive structure of the proposed regulatory scheme, we also draw from the literature on contests (e.g., sporting competitions, R&D races, or conflict), in which the study of relative performance is of primary interest (Konrad, 2009). With the size of firm i’s license being dependent on its performance relative to the average abatement

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3Of course, the standard could also be determined by the best available technology or some other benchmark. For example, the EU has recently adopted a benchmarking mechanism to determine free allocation of EU emission allowances (EUAs) under the EU ETS where the benchmark is set to reflect the average performance of the 10 per cent most efficient producers in a given sector (European Commission, 2011). While our theoretical model hinges on the benchmark being defined by the industry’s average performance, we are able to show that such instruments can ensure strong incentives to abate pollution.
efforts of the industry, the license allocation can be modeled as a contest. Doing so enables us to explicitly analyze both the static and dynamic incentives that standards stipulated via benchmarking can offer and we demonstrate that these may lead to the convergence of marginal abatement costs.

To illustrate the advantages of benchmarking, we extend our basic setup in three main settings. First, we allow firms to invest in (and adopt) new abatement technologies. We show standards stipulated via benchmarking can be just as efficient in abatement as market-based instruments. Second, we consider a changing market environment and compare total abatement under benchmarking to that under an emission tax. We find that in an expanding market, the proposed standard yields more abatement. Finally, we analyze firms’ ability to rent-seek for improved conditions under the environmental standard.\(^4\) Introducing the possibility of rent-seeking behavior, we derive conditions where, even if rent seeking is socially wasteful per se, it can improve welfare in equilibrium.

Our results add to the small but growing literature on the design of relative performance mechanisms in environmental regulation (Govindasamy et al., 1994; MacKenzie et al., 2008; D’Amato and Franckx, 2010). In this literature, the general emphasis has been on comparing relative performance mechanisms with optimal taxes. For example, both Govindasamy et al. (1994) and D’Amato and Franckx (2010) analyzed (linear) yardstick competition for nonpoint pollution. A general conclusion from this literature is that under emission uncertainty relative performance mechanisms, like benchmarking, can be more efficient than a tax. Intuitively, if there exists a sufficiently large emission error among polluters, stochastic variation can be leveled out via such regulations. Yet as we show in this chapter, even in the absence of stochastic influences, benchmarking regulation can yield considerable gains in efficiency compared

\(^4\)Related studies on the political economy of environmental regulation have analyzed both how environmental policy is determined via interest groups (e.g., Heyes, 1997; Aidt and Dutta, 2004; Aidt, 2010) as well as the creation of rents from the environmental regulation and the welfare losses incurred from rent-seeking activity (e.g., Dijkstra, 1998; Malueg and Yates, 2006; MacKenzie and Ohndorf, 2012a).
to simple emission standards. Therefore, it would be beneficial to implement standards based on benchmarking in a much larger array of applications than previously analyzed.

Our contribution is to formally rationalize the use of benchmarking regulation. When structured abatement incentives are implemented within the regulation—as outlined in this article—command-and-control policies can be effective and may even be more desirable than an environmental tax. As the majority of environmental policy uses command-and-control regulation, our approach allows policymakers to adjust existing prescriptive regulation to provide more efficient abatement incentives. Policymakers may prefer this option to introducing new (market-based) regulation, which can be both politically and financially costly as the 2011 exit of New Jersey from the Regional Greenhouse Gas Initiative (RGGI) shows. A similar decision was taken in 2014 by Australia’s government, which retracted the planned cap-and-trade scheme and instead established a benchmarking command-and-control scheme based on a fixed prize fund that is attributed to firms and project developers according to their relative abatement efforts (see Australian Government—Department of the Environment, 2014). Similar schemes are also in place in the UK—the Non-Fossil Fuel Obligation (NFFO)—and Norway—the Norwegian Carbon Procurement Facility (NorCaP) (see Mitchell, 2000; Nordic Environment Finance Corporation (NEFCO), 2013).

The chapter is organized as follows: in the next section, we set up our model of benchmarking regulation and analyze the short-term incentives it provides. In Section 2.3 we introduce an investment stage and discuss dynamic incentives of benchmarking regulation. Section 2.4 compares benchmarking to an emission tax, focusing on the abatement incentives the respective instrument provides when the size of the market changes. Section 2.5 deals with static inefficiencies and political influence. In Section 2.6 we discuss the applicability of benchmarking regulation and recent policy developments before Section 2.7 summarizes our findings and concludes.
2.2 Stipulating environmental standards via benchmarking

2.2.1 Benchmarking regulation

Let $\Phi$ denote the set of profit-maximizing firms producing a homogeneous good and engaging in monopolistic competition, where $|\Phi| = n \geq 2$. Production for this market generates pollution. Firm $i \in \Phi$ has the ability to abate this pollution at a cost $C_i(a_i)$, with $C_i'(\cdot), C_i''(\cdot) > 0$, where $a_i \geq 0$ is the abatement level of firm $i$. In the absence of regulation, the aggregate unrestricted emission level is denoted by $\bar{R} > 0$. We assume that full abatement leads to prohibitively high abatement costs.

Now consider a regulator granting a firm the right to operate in this market conditional on its performance relative to an environmental standard. The corresponding operating license can vary in scope, limiting the amount of production allowed. With lower emissions, a firm is granted a more extensive license, which allows more production and guarantees a larger share in aggregate producer surplus on the output market, denoted by $P$.

In the following, we assume the environmental standard to be established via benchmarking; more precisely, the benchmark corresponds to the average abatement level of all firms in the market. A firm may receive either more or less than the average share in aggregate producer surplus depending on its performance relative to the standard. A firm with relatively low emissions is thus rewarded for outperforming rival firms by abating more than the average. In this case it receives a share greater than $\frac{1}{n}$ of the achievable rent $P$. At the same time, an underperforming firm with below-average abatement efforts is penalized with a more restrictive operating license and

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5A number of alternative interpretations are possible. For example, $P$ could reflect a prize fund that is to be allocated to firms for their relative abatement of pollution (see the discussion of current policies in Section 2.6). Additionally, given appropriate function specifications, our framework could be extended to a case where $P$ would be endogenously determined by abatement efforts (see, Chung, 1996), in which case such a model framework could resemble, for example, a tax-and-refund scheme.

6MacKenzie et al. (2008) briefly discuss this approach in their paper on relative performance mechanisms in pollution permit markets. The relative performance approach will motivate the firms to act strategically. For a general analysis of strategic behavior in contests, see Dixit (1987).
2.2 Stipulating environmental standards via benchmarking

thus a market share less than \( \frac{1}{n} \). Obviously, in the absence of collusion, establishing such a standard via benchmarking induces competition in abatement.\(^7\)

Firm \( i \)'s market share, and thus its reward (or penalty), is determined by an allocation rule \( \Gamma(a_i, A) \), where \( A = \sum_{i \in \Phi} a_i \) is aggregate abatement. With the environmental standard being based on the average abatement level of firms, the allocation rule \( \Gamma \) deviates from an equal distribution of market shares when abatement efforts are heterogeneous and this deviation is stipulated by a function \( \varphi \).\(^8\) \( \Gamma(a_i, A) \) hence defines relative individual market shares and can be written as

\[
\Gamma(a_i, A) \equiv \frac{1}{n} + \varphi \left( \frac{a_i}{A} \right),
\]

(2.1)

where \( \varphi \left( \frac{a_i}{A} \right) \) determines the stringency of the abatement incentives depending on the level of individual abatement \( a_i \) relative to total outlays in the industry \( A \). It can be defined by any function \( \varphi \left( \frac{a_i}{A} \right) \) satisfying

\[
\sum_{i \in \Phi} \varphi(\cdot) = 0, \\
\frac{\partial \varphi(\cdot)}{\partial a_i} > 0,
\]

for all \( i \in \Phi \). These conditions imply the allocation rule \( \Gamma \) is comprised of both rewards and punishments as

\[
\varphi(\cdot) \leq 0 \text{ if } \frac{a_i}{A} \leq \frac{1}{n} \land \varphi(\cdot) > 0 \text{ if } \frac{a_i}{A} > \frac{1}{n}.
\]

(2.2)

Hence, within the benchmarking procedure, above-average abatement is rewarded

\(^7\)While incentives for collusion may exist in a concentrated industry, yardstick competition can be designed to minimize these incentives, e.g., by imposing restrictions on firms admissible choices (Shleifer, 1985). Therefore, we only consider noncooperative behavior.

\(^8\) Note that a tax/subsidy scheme could provide equivalent incentives. Given our focus on command-and-control regulation and the fact that such policy would be significantly more complicated than a conventional emission tax, this is not considered here.
while below-average performance is punished.

Without loss of generality, we restrict our analysis to \( n = 2 \) firms and define the set of firms \( \Phi = \{X, Y\} \).\(^9\) In addition, we assume that in determining rewards and penalties, \( \varphi \) is a function of the difference between individual abatement \( a_i \) and average abatement of all firms. Therefore, if the scope of the license is determined via benchmarking, we can define the allocation rule as

\[
\Gamma(a_i, A) = \frac{1}{2} + \frac{a_i - \frac{A}{n}}{A} = \frac{a_i}{a_i + a_{-i}} \quad \text{for} \quad i, -i \in \Phi. \tag{2.3}
\]

The extent of a firm’s license is thus solely driven by average abatement and deviations from this benchmark. As a result, firm \( i \)'s choice of abatement indirectly determines its output; the scope of its licensed operations, therefore, also determines its absolute share of producer surplus, \( \nu_i \). We assume that a firm choosing not to abate is not eligible for an operating license and is, thus, effectively banned from the market. Interestingly, benchmarking as described in (2.3) is similar to a standard Tullock contest (Tullock, 1980); a firm’s share in producer surplus \( \nu_i \) for \( i \in \Phi \) and \( -i \in \Phi \backslash \{i\} \) is thus given by

\[
\nu_i(a_i, a_{-i}) = \begin{cases} 
 \frac{a_i}{a_i + a_{-i}} P & \text{if } \max\{a_i, a_{-i}\} > 0, \\
0 & \text{otherwise.} 
\end{cases} \tag{2.4}
\]

Note that for (2.4) to fully determine market shares, a sufficient condition is that the mark-up per unit of output as well as total producer surplus are constant.\(^10\)

For the remainder, we allow abatement costs to be of the form, \( C_i(a_i) = k_i \cdot a_i^2 \),

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\(^9\)The restriction to the two-firm case is purely for ease of representation. As shown in Appendix 2.B, our results extend to the case of \( n > 2 \).

\(^10\)When interpreted as a production license (an assumption we relax in Section 2.6), the natural application of the proposed instrument would be the regulation of the production of a homogeneous good. In these circumstances, it seems plausible to assume that producers have similar production costs and, therefore, earn the same mark-up per unit sold. Multiplied with a given demand for the good (or a legally restricted quantity of the output), this mark-up defines the producer surplus, which we hence assume to be constant and exogenous. We relax the first assumption in Section 2.4.
2.2 Stipulating environmental standards via benchmarking

where \( k_i \) denotes the abatement technology available to firm \( i \). The firm’s objective then is to choose \( a_i \) so as to maximize its payoff function \( \pi_i = v_i(a_i, a_{-i}) - C_i(a_i) \). Given that \( C_i(a_i) \) is continuous and monotonic, its inverse function is well-defined: 
\[
C_i(a_i) = c_i \iff a_i = C_i(c_i)^{-1} = k_i^{-\frac{1}{2}} \cdot c_i^\frac{1}{2}.
\]
Using the parametrization \( m_i = k_i^{-\frac{1}{2}} \), we can rewrite (2.4) to express \( i \)'s share in producer surplus as follows:
\[
v_i(c_i, c_{-i}) = \begin{cases} 
\frac{m_i c_i^\frac{1}{2}}{m_i c_i^\frac{1}{2} + m_{-i} c_{-i}^\frac{1}{2}} P & \text{if } \max\{c_i, c_{-i}\} > 0, \\
0 & \text{otherwise.}
\end{cases} 
\] (2.5)

With the attribution rule now being a function of abatement costs, solving the game is straightforward.\(^{11}\) The firm’s optimization determines the equilibrium abatement cost level (denoted by tilde) as
\[
\tilde{c}_i = \tilde{c}_{-i} = \frac{P \sqrt{k_i k_{-i}}}{2 \left( \sqrt{k_i} + \sqrt{k_{-i}} \right)^2},
\] (2.6)
which yields the optimal abatement level
\[
\tilde{a}_i = \left[ \frac{P \sqrt{k_{-i}}}{2 \sqrt{k_i} \left( \sqrt{k_i} + \sqrt{k_{-i}} \right)^2} \right].
\] (2.7)

The individual equilibrium levels of abatement effort and abatement costs enable us to also derive their respective totals. Benchmarking regulation results in the following equilibrium levels of aggregate abatement, \( \tilde{A} \), and total abatement costs, \( \tilde{C} \):
\[
\tilde{C} = \tilde{c}_X + \tilde{c}_Y = \frac{P \sqrt{k_X k_Y}}{(\sqrt{k_X} + \sqrt{k_Y})^2},
\] (2.8)
\[
\tilde{A} = \tilde{a}_X + \tilde{a}_Y = \sqrt{\frac{P}{2 \sqrt{k_X k_Y}}},
\] (2.9)

\(^{11}\)It is easy to verify that the second-order condition is fulfilled and \( \frac{\partial^2 \pi_i}{\partial c_i^2} < 0. \)
With benchmarking regulation, larger values of the exogenous rent $P$ thus provide stronger abatement incentives for both firms. On the other hand, if $k_i$ is large, i.e., if firm $i$ is inefficient in abating pollution, intuitively $i$ abates comparatively little. Depending on the relative efficiency of the abatement technologies available to the two firms, a larger value of the rival’s abatement cost parameter $k_{-i}$ may or may not incentivize greater abatement effort by $i$: when $k_i > k_{-i}$, the higher $k_{-i}$, the higher are the returns on additional abatement effort by $i$ in terms of market share. In contrast, when $k_i < k_{-i}$ and $i$ is thus more efficient in abating pollution, larger levels of $k_{-i}$ motivate relatively less abatement by $i$ due to $i$ knowing of its competitive advantage and anticipating little abatement efforts by the other firm.

In direct contrast to conventional emission standards that require the setting of uniform emission levels among firms independent of their abatement cost, benchmarking regulation leads to differentiation in abatement efforts. As abatement by the high-cost firm is lower than that by the low-cost firm, standards stipulated via benchmarking are generally more efficient than a conventional emission standard. Nevertheless, as long as firms are heterogeneous in terms of available abatement technologies, benchmarking does not yield the sharing of cost as required by the socially optimal first-best solution, where the sum of aggregate damage from pollution and aggregate abatement cost is minimized. The optimal solution, therefore, requires an equalization of marginal cost, whereas standards stipulated via benchmarking lead to equal abatement cost, $c_X = c_Y$. The remaining inefficiency can hence be explained by the fact that, under benchmarking regulation, the standard (yardstick) is defined by competition over abatement itself rather than its marginal cost.

---

12 It is straightforward to show that any level of abatement is achieved at a lower total cost when the regulatory instrument is a standard established via benchmarking rather than a conventional command-and-control policy.
2.2 Stipulating environmental standards via benchmarking

2.2.2 Relative performance in abatement

In order to investigate the deviation of abatement under benchmarking regulation from the first-best level of abatement, we introduce a damage function $D(A)$ with $D'(A) < 0$ and $D''(A) > 0$, where $A = a_X + a_Y$. For our purposes, we use a quadratic representation of the damage function given by $D(A) = \frac{(E - Ab)^2}{2b}$, where $b > 0$ is a parameter that determines slope and convexity of the damage function, and $E$ is the intercept of the marginal damage function. $E$ can be interpreted as a parameter determining the level of damage, where $R = \frac{\bar{E}}{b}$ is the unrestricted level of emissions.

The horizontal aggregation of the individual cost functions yields the aggregate abatement cost $C(A)$:

$$C(A) = c_X + c_Y = k_X a_X^2 + k_Y a_Y^2 = \frac{A^2 k_X k_Y}{k_X + k_Y}. \quad (2.10)$$

The first-best aggregate abatement level, denoted by $A^*$, is then determined by minimizing the sum of aggregate abatement costs and environmental damage. Solving the first-order condition for $A$ yields the first-best level of aggregate abatement

$$A^* = \frac{\bar{E}(k_X + k_Y)}{b(k_X + k_Y) + 2k_X k_Y}. \quad (2.11)$$

To compare $A^*$ with the equilibrium abatement level under benchmarking, $\tilde{A}$, let us define $\Delta_A$ as the difference between the first-best aggregate abatement level and the abatement level achieved by benchmarking regulation. $\Delta_A$ is thus given by

$$\Delta_A = A^* - \tilde{A} = \frac{\bar{E}(k_X + k_Y)}{b(k_X + k_Y) + 2k_X k_Y} - \sqrt{\frac{P}{2\sqrt{k_X k_Y}}}. \quad (2.12)$$

Note that $\Delta_A$ can be either positive or negative. This indicates that the incentives to abate under the proposed benchmarking regulation can actually be too strong. Clearly, if the level of damage from unregulated emissions—as determined by $\bar{E}$—is
large enough, abatement under benchmarking regulation is lower than the first-best level. In contrast, if the achievable rent $P$ is large, benchmarking provides strong incentives to reduce emissions and as a result, abatement can ultimately reach inefficiently high levels, i.e., over-abatement can occur. Intuitively, as the intensity in individual abatement efforts is driven by the attainable profit, the resulting high degree of competition leads to excessively high levels of abatement compared to the first-best optimum. In the opposite case, when production results in relatively little overall surplus $P$, the operating license has a low value and thus benchmarking regulation does not incentivize sufficient abatement. Incidentally, $\Delta A$ could also be zero such that benchmarking regulation would lead to the first-best level of abatement. Note, however, that cost-efficiency would not be achieved in this case as long as marginal abatement costs differ.

While equation (2.12) shows that environmental standards can provide strong incentives for abatement, they are still likely to be inefficient on two grounds: first, they do not reduce abatement at least cost and second, we show that, if abatement technologies are fixed (e.g., regulation is set in the middle of the firm's investment cycle), benchmarking can lead to an additional inefficiency in that it can ultimately incentivize abatement levels exceeding the socially optimal. The remainder of the chapter analyses both the incentives of benchmarking regulation to adopt new technologies as well as the impact of the political process on the additional short-term inefficiency.

2.3 Benchmarking regulation with endogenous adoption of technology

The previous section outlined the short-term effects of benchmarking regulation with fixed abatement technologies. Yet an important aspect of policy comparison focuses on dynamic incentives, i.e., the incentives to create and adopt new technologies over
2.3 Benchmarking regulation with endogenous adoption of technology

By defining the industry’s average abatement effort as the environmental standard and allowing the endogenous choice of the technology parameter, $k_i$, we show that the proposed allocation rule $\Gamma$ provides incentives to create and adopt new abatement technologies.\(^{13}\)

### 2.3.1 Incentivizing investment through benchmarking regulation

To begin, consider an investment function $k_i(I_i)$ that maps individual investment—denoted $I_i$—to the technology parameter $k_i$ and fulfills $k_i'(\cdot) < 0$ and, therefore, $c_i'(I_i) < 0$. Prior to benchmarking regulation, the firm chooses its investment expenditure to balance the cost of investing in new technologies with the benefits from being able to abate pollution more cheaply. Given the allocation rule $\Gamma$ is common knowledge, firms have an expectation of the benchmarking outcome when deciding on their investment expenditure in the first stage. We thus solve by backward induction where the solution to the second stage is analogous to Equation (2.6). Firm $i$’s optimization problem hence reduces to:

$$
\max_{I_i} \pi_i(k_i, I_i),
$$

where

$$
\pi_i(k_i, I_i) = \nu_i(\tilde{c}_i(I_i), \tilde{c}_{-i}(I_{-i})) - \tilde{c}_i(I_i) - I_i
$$

$$
= \frac{P \left( 2k_{-i}(I_{-i}) + \sqrt{k_i(I_i) \cdot k_{-i}(I_{-i})} \right)}{2 \left( \sqrt{k_i(I_i)} + \sqrt{k_{-i}(I_{-i})} \right)^2} - I_i. \tag{2.14}
$$

Similar to Fu and Lu (2009), we define a class of functions $k_i(I_i) = \frac{1}{\gamma_i + \mu I_i}$ for $i \in \Phi$ where parameters $\gamma_i \in [0, \infty)$ and $\mu \in (0, \infty)$ are constants. The parameter $k_i$ continues to specify the abatement technology, but $\gamma_i$ now represents the initial level of technological knowledge. If the firm has a high level of technological knowledge at

\(^{13}\)Note that we do not consider technological spillovers. If they existed in our model, we would expect investment to decrease as spillover effects would reduce the competitive advantage one could gain by investing in a more efficient technology.
its disposal, $k_i$ (and thus abatement cost) is relatively small. The parameter $\mu$ determines the efficiency of investing in additional knowledge and technological progress. Regardless of the size of $\mu$, investment $I_i$ reduces firm $i$’s abatement cost, allowing it to use its expenditure on abatement more efficiently in the ensuing competition in emission abatement.

Solving the maximization problem defined in equation (2.13) yields an interesting result, which we summarize in the following proposition:

**Proposition 1.** Benchmarking regulation with endogenous technology choice, characterized by a class of investment functions $k_i(I_i) = \frac{1}{\gamma_i + \mu I_i}$, incentivizes firms to invest so as to equalize their (marginal) abatement costs, i.e., they invest $I_i^* = \frac{\mu P - 8\gamma_i}{8\mu}$ in order to adopt the same optimal abatement technology given by

$$k_i^* = k_{i-}^* = \frac{8}{\mu P}. \quad (2.15)$$

**Proof.** See Appendix 2.A.

This result identifies conventional regulation that has the potential to achieve efficiency in abatement without the aid of an emissions tax or tradable licenses. By (repeatedly) basing environmental standards on benchmarking, the regulator can provide incentives for firms to invest in new abatement technologies in order to increase abatement and thereby their market shares.\(^{14}\) Ultimately, firms only differ in their investment decision while their resulting abatement costs—and, therefore, marginal abatement costs—are the same. Note that this result does not hold in general. Yet we show that, given the specification of pre-contest investment adopted from Fu and Lu (2009), stipulating an environmental standard via benchmarking can—just like market-based instruments—lead to the first-best level of abatement while equalizing marginal abatement costs.

\(^{14}\)Note that the regulator does not prescribe the use of any specified technology such as in a regime where best available control technologies (BACT) are used.
2.3 Benchmarking regulation with endogenous adoption of technology

Note also that despite obtaining the same share of surplus on the product market, firms’ final profits differ. For abatement costs $c_i(k_i^*)$, the profit of firm $i$ is given by $\pi_i^* = \frac{P}{4} + \frac{\gamma_i}{\mu}$ and allows firms with initially more efficient abatement technologies to earn a larger net profit.

### 2.3.2 Efficient benchmarking regulation

With investment yielding equal abatement costs, the necessary condition for efficient benchmarking regulation is satisfied. To derive the sufficient condition, we allow the regulator to adjust the allocation rule defined in Equation (2.3), thereby strengthening (or weakening) the incentives to abate as needed in order to reach the first-best level of abatement.\(^{15}\) To optimize the incentive structure, the regulator thus increases (or decreases) the rewards (and penalties) awarded for performing better (worse) than the industry average.

A general allocation rule accounting for such alternative incentive structures is given by

$$\Gamma_q = \frac{a_i^q}{a_i^q + a_{-i}^q},$$

(2.16)

where $q$ is a decision variable of the regulator and enables him to control the strength of the abatement incentives that benchmarking regulation provides. Note that a restriction on $q$ is needed to ensure the mechanism to be consistent in its incentives: as a sufficient condition for an interior solution to exist, we hence introduce the technical assumption that $q < \frac{2}{\ln(\sigma)}$, where $\sigma$ defines the relative size of $k_X$ compared to $k_Y$ (i.e., $k_Y = \sigma \cdot k_X$; see Appendix 2.A).

Given the generalized form of the allocation rule $\Gamma_q$, total abatement by the two firms now depends on $q$. Using Equation (2.16), we can derive equilibrium levels for abatement and abatement costs as well as their respective totals: $\tilde{a}_{i,q}$, $\tilde{A}_q$, $\tilde{c}_{i,q}$, and

\(^{15}\)Alternatively, to yield the first-best level of abatement, the regulator could simply limit the scope of aggregate operating licenses and thus the rent $P$. 
\( \hat{C}_q \), which are provided in Appendix 2.A. We then introduce investment and—using backward induction with the solution to the second stage given by the equilibrium levels \((\hat{a}_{i,q}, \hat{A}_q, \hat{c}_{i,q}, \hat{C}_q)\)—solve the following optimization problem of firm \( i \):

\[
\max_{k} \pi_i(k, I_i) \tag{2.17}
\]

where

\[
\pi_i(k, I_i) = v_i(\hat{c}_{i,q}(I_i), \hat{c}_{i,q}(I_{-i})) - \hat{c}_{i,q}(I_i) - I_i
\]

\[
= \frac{P \left( 2k^2_i(I_{-i}) + (2 - q)k^2_i(I_i)k^2_{-i}(I_{-i}) \right)}{2 \left( k^2_i(I_i) + k^2_{-i}(I_{-i}) \right)^2} - I_i. \tag{2.18}
\]

Taking into account that firms invest so as to equalize marginal abatement costs, the total level of abatement is given by \( \hat{A}_q = \sqrt{Pq^2} \). Equating \( \hat{A}_q \) and the first-best level of abatement, \( A^* \), allows us to derive the optimal incentive structure, which we define in the following proposition:

**Proposition 2.** Under benchmarking regulation with endogenous technology choice, the regulator can ensure that the first-best level of abatement is reached at minimal abatement costs if the allocation rule in Equation (2.16) is determined by

\[
q^* = \frac{2\hat{E}k_X}{P(b + k_X)^2}. \tag{2.19}
\]

Naturally, \( q^* \) is decreasing in \( P \). Additional incentives via a more convex allocation rule are not needed when \( P \) is large. In fact, a value of \( q^* \) smaller than one—equivalent to concave payoffs—could be optimal if initial incentives to abate are very strong. The opposite results hold for a large level of damage as determined by \( \hat{E} \).

While the policy instrument defined by Equation (2.16) and Proposition 2 may be complex, it demonstrates the potential of command-and-control regulation to be efficient. Just like for a Pigouvian tax, however, the informational requirement for the optimal incentive structure is extensive. In fact, unlike efficient taxation, first-best...
benchmarking regulation requires observability of total surplus $P$. The latter could limit the practical applicability of efficient benchmarking regulation, but it does not reduce the general advantage of standards stipulated via benchmarking over conventional command-and-control regulation.

2.4 Comparing benchmarking regulation and emission taxes

In this section we compare the performance of a standard stipulated via benchmarking to that of an emission tax. As common within the literature on instrument comparisons (e.g., Requate, 2005), we assume that the choice of abatement is independent of the choice of output, i.e., the cost of abatement is a function of $a_i$ and $k_i$ only.

Under an emissions tax, $\tau$, marginal abatement costs are equalized. Thus $\tau = C'(A)$ where $C(A)$ is defined in equation (2.10). The general form of the abatement level under tax regulation is then given by

$$A_T = \frac{\tau(k_X + k_Y)}{2k_Xk_Y}. \quad (2.20)$$

Note that the abatement level under tax regulation is—unlike the abatement level imposed by benchmarking regulation—indepedent of the value of the rent. The latter implies that in an expanding market, benchmarking could incentivize more equilibrium abatement than an emission tax.

This finding becomes apparent when considering the following: assume that the value of the rent is exogenous, but no longer constant. Instead the product market is expanding (or contracting) and the regulator—and possibly the firms—can anticipate this expansion (contraction). The market growth is denoted $\delta_t \geq -1$ for time period $t$. The value of the rent is then given by

$$P_t = \epsilon \cdot (1 + \delta_t)\bar{Q}, \quad (2.21)$$
where $\epsilon$ is a constant mark-up on the units sold while $\bar{Q}$ is the exogenous, initial, aggregate number of units that can be sold on the market. By definition, $\delta_0 = 0$, i.e., $P_0 = \epsilon \cdot \bar{Q}$. Note that the level of unregulated emissions, $\bar{R}_t$, depends on the units sold on the market; therefore, $\bar{R}_t$ is also a function of $\delta_t$ and at time $t$, we have $\bar{R}_t = \bar{R}_t(\delta_t)$ satisfying $\frac{\partial \bar{R}_t}{\partial \delta_t} > 0$.

The question we seek to address is how, in a changing market environment, the abatement levels incentivized by benchmarking regulation and emission taxes, respectively, differ from each other. Intuitively, as a relative performance mechanism, benchmarking regulation should motivate more abatement than a tax, which is independent of the abatement of individual firms. To show this, first consider abatement under an emission tax. At time $t = 0$, the emission level under a tax regime is given by $\bar{R}_0(0) - A_\tau$, while at time $t = 1$, remaining emissions are $\bar{R}_1(\delta_1) - A_\tau$. The difference in emissions net of abatement when an emission tax is implemented is thus given by

$$\Delta_\tau = \bar{R}_1(\delta_1) - A_\tau - \bar{R}_0(0) + A_\tau = \Delta \bar{R},$$

(2.22)

where $\Delta \bar{R}$ is simply the difference between unregulated emissions in periods $t = 0$ and $t = 1$, respectively. If the market is expanding and thus $\delta_1 > 0$, then $\Delta_\tau$ is positive and emissions increase.

Second, consider the proposed standard stipulated via benchmarking. In a growing market, emissions under this policy regime still increase, however, to some degree, the regulatory instrument automatically adjusts to the new conditions: at time $t$, remaining emissions are defined by $\bar{R}_t(\delta_t) - \bar{A}_t$, where—similar to aggregate abatement defined in equation (2.9)—total abatement is $\bar{A}_t = \sqrt{\frac{(1 + \delta_t)^2}{2\sqrt{X_k Y_k}}} = \sqrt{(1 + \delta_t)} \cdot \bar{A}_0$. Therefore, the difference in remaining emissions under benchmarking regulation between
Comparing benchmarking regulation and emission taxes

The period $t = 0$ and $t = 1$ is given by

$$\Delta_B = \bar{R}_1(\delta_1) - \sqrt{(1 + \delta_1)} \cdot \bar{A}_0 - \bar{R}_0(0) + \bar{A}_0$$

$$= \Delta \bar{R} - \left( \sqrt{(1 + \delta_1)} - 1 \right) \bar{A}_0. \quad (2.23)$$

Clearly, if the market is expanding, this difference is again positive. Nevertheless, given there is no change in policy, an environmental standard based on benchmarking is the more sustainable policy in that it leads to more emission abatement than the tax.\(^\text{16}\) The latter is due to its inherent incentive structure that motivates additional abatement when attainable producer surplus increases. This finding is summarized in the following proposition:

**Proposition 3.** If the regulator implements a permanent policy to regulate emissions and the market is expanding (contracting) at a rate $\delta_t$, an environmental standard stipulated via benchmarking yields more (less) abatement of emissions than an environmental tax. The difference in abatement levels is given by

$$\Delta_\tau - \Delta_B = \left( \sqrt{(1 + \delta_t)} - 1 \right) \bar{A}_0.$$

Growth rate $\delta_t$ thus drives the relative advantage (or disadvantage) of benchmarking regulation. Note that—in an expanding market—the incentive to abate more under benchmarking would be enhanced if investment in new technologies was possible. The larger achievable rent would motivate further investment in efficient abatement technologies and, therefore, the resulting abatement under benchmarking regulation would be even greater. On the other hand, if the regulator expects the market to contract (i.e., $\delta_t < 0$), an environmental tax is the more effective policy to reduce emissions.

\(^\text{16}\)Obviously, if the tax was truly Pigouvian, i.e., first-best efficient, increased abatement would be undesirable and benchmarking could lead to abatement beyond the socially optimal; but this would be the standard textbook comparison of an optimal instrument with a much more restrictive policy. One can argue, however, that environmental taxes are typically well below their Pigouvian levels (e.g., Ciocirlan and Yandle (2003)), which motivates our comparison of two suboptimal regulatory policies.
as incentives to innovate or to adopt more efficient technologies are reduced.

2.5 Extension: benchmarking and rent seeking

After considering dynamic incentives of benchmarking regulation, we revisit its potential short-term inefficiencies, namely, abatement incentives that exceed the socially optimal. To capture the fact that firms frequently expend effort trying to dilute environmental standards or to receive exemptions from existing regulation, we allow firms the ability to adjust the allocation rule $\Gamma$ in their favor by investing in rent-seeking effort. We then analyze the impact of rent seeking on the level of total abatement.

2.5.1 Rent seeking within the allocation rule

Consider a model where the attribution of market shares is not only determined by the scope of the operating license, which depends on abatement effort, but also by individual rent-seeking effort, denoted $s_i$.\(^{17}\) The effectiveness of the latter depends on the exogenous parameter $\alpha \in [0, 1]$, which alters the degree of influence between abatement and rent-seeking efforts and, therefore, can be seen as a measure of the political system’s inherent likelihood of being influenced by rent seeking.\(^{18}\) For example, with $\alpha = 1$—equivalent to rent seeking having no impact on regulation—the model reduces to that considered in Section 2.2, whereas $\alpha = 0$ describes a case where political rent seeking is the unique influence on market share. Combining these elements,

\(^{17}\)Despite rent-seeking efforts typically being viewed as welfare decreasing, the second choice variable, $s_i$, can be interpreted more generally as effort, which could have positive or negative welfare implications. We show that even if the second instrument is welfare decreasing, its use can still improve welfare overall.

\(^{18}\)One could think of the regulator having the power to choose $\alpha$, in which case $\alpha$ would express the regulators valuation of abatement and rent seeking, respectively. Alternatively, one could view $\alpha$ as being exogenous and simply show that $\alpha < 1$ can increase the efficiency of the mechanism. We take the latter approach.
2.5 Extension: benchmarking and rent seeking

firm i’s absolute share of producer surplus, \( \bar{\nu}_i \), is now given by:29

\[
\bar{\nu}_i = \begin{cases} 
\frac{\alpha}{m_i c_i^2} + \frac{(1 - \alpha)s_i}{s_i + s_{-i}} \right) P & \text{if } \max(c_i, c_{-i}, s_i, s_{-i}) > 0, \\
0 & \text{otherwise.}
\end{cases}
\] (2.24)

As rent seeking is typically assumed to be welfare decreasing, a priori, it appears as if \( \alpha \) should always be one: rent seeking should not influence the allocation rule \( \Gamma \). Yet we prove that optimally \( \alpha \leq 1 \), i.e., the dilution of individual environmental benchmarking regulation through political lobbying may be justified as it can reduce short-term inefficiencies and improve welfare.

Firm i’s payoff is given by \( \bar{\nu}_i(c_i, c_{-i}, s_i, s_{-i}) - c_i - s_i \) and optimization yields the equilibrium levels \( \hat{c}_i, \hat{s}_i, \) and \( \hat{a}_i \), which are defined in Appendix 2.A. The associated equilibrium levels of aggregate abatement, \( \hat{A} \), abatement cost, \( \hat{C} \), and rent seeking, \( \hat{S} \), are given by the following equations:

\[
\hat{C} = \frac{\alpha P \sqrt{k_X k_Y}}{\left( \sqrt{k_X} + \sqrt{k_Y} \right)^2},
\] (2.25)

\[
\hat{A} = \sqrt{\frac{\alpha P}{2 \sqrt{k_X k_Y}}},
\] (2.26)

\[
\hat{S} = \frac{(1 - \alpha) P}{2}.
\] (2.27)

2.5.2 The welfare effects of rent seeking

As both the abatement and rent-seeking efforts of the firms depend on \( \alpha \), the latter also drives social welfare. To minimize aggregate social costs, we, therefore, determine

29Note that (2.24) requires a given degree of substitutability between the cost of rent seeking and abatement. For a more general formulation, see Gerigk et al. (2013). An alternative specification would allow both choice variables to be multiplicative; for an example, see Arbatskaya and Mialon (2010).
the second-best optimal level of $\alpha$. The objective function is given by\textsuperscript{20}

$$
\min_{\alpha} D(\hat{A}) + \hat{C} + \hat{S}, \text{ s.t.}
\begin{align*}
\alpha &\leq 1, \\
\alpha &\geq 0.
\end{align*}
$$

For ease of notation and without loss of generality, we again assume $k_Y = \sigma \cdot k_X$, where $\sigma$ is defined as before. Our results regarding the optimal level of $\alpha$ are summarized in the following proposition:

**Proposition 4.** The optimal level of $\alpha$ is

$$
\alpha^* = \begin{cases} 
0 & \text{if } \bar{E} = 0, \\
\frac{2E^2}{P \sqrt{\sigma k_X^2} \left(-2 + \frac{b}{\sqrt{\sigma k_X^2}} + \frac{4\sqrt{\sigma}}{(1 + \sqrt{\sigma})^2}\right)} & \text{if } 0 < \bar{E} < \sqrt{P \cdot \Omega}, \\
1 & \text{if } \bar{E} \geq \sqrt{P \cdot \Omega},
\end{cases}
$$

where

$$
\Omega = \frac{\sqrt{\sigma k_X^2}}{2} \left(-2 + \frac{b}{\sqrt{\sigma k_X^2}} + \frac{4\sqrt{\sigma}}{(1 + \sqrt{\sigma})^2}\right)^2.
$$

**Proof.** See Appendix 2.A.

Proposition 4 contradicts the intuition that rent seeking, which decreases welfare, should not affect the allocation of market shares in equilibrium.\textsuperscript{21} From (2.31), inefficiencies in benchmarking regulation are driven by the size of the rent $P$ and the level of damage parameter $\bar{E}$. For a low $\bar{E}$, the benefits from abatement are rather small and eventually fall short of its marginal cost. Ultimately, if $\bar{E} = 0$, abatement is unnecessary.

\textsuperscript{20}Note that $\hat{S}$ only accounts for the direct monetary cost of rent seeking. If there were additional welfare costs related to rent seeking, of course, the range for which the latter has the potential to increase welfare would be reduced.

\textsuperscript{21}Note that this follows from the second-best argument that two distortionary factors may achieve an outcome closer to the first-best outcome.
2.5 Extension: benchmarking and rent seeking

ecessary and ideally discouraged by \( \alpha = 0 \). Similarly, if attainable profit \( P \) is large such that \( \sqrt{P \cdot \Omega} > \bar{E} \), regulation via benchmarking induces a fierce contest that ultimately leads to abatement efforts exceeding the socially optimal. As the cost of abatement increases exponentially, it can at some point become welfare improving to bear—up to a limit—the social cost of rent seeking instead.

2.5.3 Total abatement efforts with rent seeking

From Proposition 4, we conclude that \( \alpha^* \in (0, 1] \). Hence, we established that rent seeking can increase welfare; however, it remains unclear if the optimal level of rent seeking prevents over-abatement and whether it can even yield the first-best level of aggregate abatement. Considering this question, we find that rent seeking can increase efficiency only if aggregate abatement levels exceed the social optimum. Hence, the optimal level of \( \alpha \) can reduce—but not prevent—short-term inefficiencies and thus never yields the first-best level of abatement.\(^{23}\) These findings are summarized in the following proposition:

**Proposition 5.** When \( \alpha \) is at its socially optimal level, rent seeking can reduce but never prevent over-abatement of emissions; i.e., we can identify the following parameter ranges:

- if \( \frac{\bar{E}}{P} < \Omega < \Psi \), we have an interior solution where \( \alpha^* < 1 \) and \( A^* < A(\alpha^*) \),
- if \( \Omega \leq \frac{\bar{E}}{P} < \Psi \), we have a corner solution where \( \alpha^* = 1 \) and \( A^* < A(\alpha^*) \), and
- if \( \Omega < \Psi \leq \frac{\bar{E}}{P} \), we have a corner solution where \( \alpha^* = 1 \) and \( A^* \geq A(\alpha^*) \).

where

\[
\Psi = \frac{(b\sigma + b + 2\sigma kX)^2}{2kX(1 + \sigma)^2\sqrt{\sigma}}
\]  

\((2.33)\)

**Proof.** See Appendix 2.A. \( \Box \)

\(^{22}\)Of course, regulation would not be needed, therefore, the proposed mechanism would not actually be employed.

\(^{23}\)It is easy to show that the results extend to the case with investment.
2.6 Discussion

Our analysis has shown the improved efficiency of command-and-control regulation stipulated via benchmarking. Even in its simplest form, abatement costs are equalized among competitors and, hence, even though marginal abatement costs may still differ, any given abatement level is achieved at lower cost than under a conventional standard that prescribes an equal sharing of the abatement target. To provide additional insights, we now discuss the relative strengths and weaknesses of the proposed approach, including the practical applicability.

2.6.1 Model assumptions

Underlying most of our results is the assumption of a constant market surplus $P$. Although we identify circumstances in which this assumption seems plausible or even natural, it is, of course, limiting and partly depends on the produced good being homogeneous.\footnote{If benchmarking regulation is to allocate production licenses, the assumption of homogeneity on the output market is crucial.} If firms differed sufficiently with respect to their earning potential on the market or if there was asymmetric information regarding the market surplus—i.e., if firms differed in their valuation of $P$—the proposed regulation may not work.

In addition, inefficiencies could arise if exogenous shocks occurred, which would reduce the rent $P$. As long as the expectations of all firms and the regulator regarding these shocks were the same, it would not necessarily deter the optimal market distribution. It could, however, cause problems for firms that have committed to (or realized) large abatement projects but are now faced with suddenly reduced earning potential. In that case, benchmarking regulation might be less flexible than market instruments.\footnote{Note, however, that market instruments may also incentivize large abatement projects that could cause similar problems if exogenous shocks occurred. Under any instrument there could then be an incentive to renegotiate the regulatory burden. As benchmarking regulation is based on individual contracts between firms and the regulator, it might be more prone to renegotiation than universal policies.} This shortcoming is partly driven by the assumption that the decisions
2.6 Discussion

on abatement and output levels are independent. Although this is common in the literature, one could also envision cases where output and abatement are (directly) correlated. In that case, minor modifications of our model allow for $P$ to be endogenously determined by abatement efforts (see Chung, 1996). Such a framework could then, for example, resemble the Swedish NO$_X$ tax scheme in which energy producers first pay a high tax on NO$_X$ emissions before the proceeds of this tax are refunded to the producers according to their relative environmental performance (see Sterner and Isaksson, 2006). Clearly, in that case the distributable rent depends on abatement efforts, yet the ensuing sharing of the rent aligns closely with our theoretical model. At the same time, for carbon offset projects or the installation of stack filter technology, assuming independence of abatement and the quantity produced (and thus $P$) seems plausible.

2.6.2 Applicability of benchmarking regulation

Looking at the actual implementation of the proposed regulation, first, a definition of the relevant competitors, i.e., defining the bounds of the industry, is typically needed. Although this may appear demanding, environmental policies targeted at certain industries are commonplace and given that benchmarking regulation should be aimed at the production of a homogeneous good, defining the industry seems feasible. In such a case (e.g., the production of electricity), the relevant sector is easily defined and the installation of filter technology or other abatement efforts, such as the switch to lower emission combustibles, are likely to be observable and could be contracted.

Furthermore, given the importance of firms’ abatement levels $a_i$ as the determinant of the scope of their production licenses, it is essential for the regulator to be able to measure $a_i$.\(^{26}\) This is equally necessary and follows equivalent procedures un-

\(^{26}\)As is standard in the analysis of environmental regulation, $a_i$ is defined as the difference between emissions from production under a baseline scenario and a scenario in which firm $i$ takes measures to abate its pollution. While this is typically measured per firm, the interpretation of $a_i$ as abatement per unit of production is equally possible.
der other regulatory schemes, such as emission taxes, and could either be done via
direct monitoring or through calculations based on input use.\textsuperscript{27} With abatement be-
ing imperfectly observable, however, firms have an incentive to misreport their actual
emissions/abatement, which has been shown to be a considerable issue without ap-
propriate enforcement mechanisms (see, e.g., Gray and Shimshack, 2011; Telle, 2013).
The incentive for false reporting, however, is likewise present under any other policy
instrument, such as emission taxes or cap-and-trade schemes (see, e.g., Harford, 1978;
Malik, 1992; Heyes, 2000; Macho-Stadler and Perez-Castrillo, 2006; MacKenzie and
Ohndorf, 2012b). In fact, one can show that under such schemes this problem may
be even more pronounced than for standards stipulated via benchmarking: whereas
under benchmarking regulation increased monitoring effort strictly decreases misre-
porting, this is not the case for emission taxes (see, e.g., Stranlund et al., 2009).\textsuperscript{28}
Nevertheless, similar monitoring and enforcement measures are needed for the pro-
posed benchmarking regulation as are used for conventional regulatory policies and
while these may not be able to fully eliminate fraud, the instrument we suggest may
be less prone to false reporting of emissions than other policies.

Note, however, that additional monitoring and enforcement issues arise if the regu-
lator wanted to implement efficient benchmarking regulation. Similar to other policy
instruments, efficiency would require supplementary information, in particular, the
knowledge of marginal abatement costs. However, in order to reach the first-best
level of abatement under benchmarking regulation and, at the same time, to pro-
vide adequate incentives for technology adoption, observability of the total surplus
$P$ and full enforcement of market shares would also be necessary. While meeting

\textsuperscript{27}An extensive description of possible measurement methods is given in Commission Regulation (EU)
No. 601/2012.
\textsuperscript{28}With market instruments, the marginal benefit of over-reporting of abatement is constant and equal
to the tax rate or permit price. Under benchmarking regulation, however, the incentive to over-state
abatement is decreasing because the market share is concave in reported emissions. As a result, any
positive level of monitoring achieves a reduction in misreporting, whereas with an emission tax there is
no compliance by the firms unless the expected fine, a function of monitoring effort, exceeds the tax rate.
these additional requirements may be feasible in markets for homogeneous goods for
which sufficient output data is available (e.g., the power market), the applicability of
benchmarking regulation—which invariably improves the efficiency and effectiveness
of environmental standards—as an efficient regulatory tool is certainly limited. In ad-
ddition, the need to enforce the production licenses adds to the administrative costs of
the proposed instrument. Whereas the regulator also has to ensure the clearing of a
firm’s emission tax bill or the rendering of its emission allowances, enforcing a firm’s
market share is likely to be a more complex and thus more expensive administrative
burden.

Most of the limitations of our theoretical framework are, however, particular to
the interpretation of the attribution rule as defining the scope of a production license.
Discussing our model in a more general framework and in the context of recent de-
velopments in climate policy not only shows how the assumptions of our model can
be relaxed but also how they indeed reflect some elements of contemporary regu-
lation. In particular, accepting the assumption of $P$ being constant seems natural
when considering fixed value funds that are used by regulators to pay for pollution
abatement. Such schemes exist, for example, in the UK (the Non-Fossil Fuel Obli-
gation, NFFO) and Norway (the Norwegian Carbon Procurement Facility, NorCaP)
and, more recently, a similar instrument has been introduced in Australia as the then
government’s flagship climate policy (Australian Government—Department of the En-
vironment, 2014). The Australian Emission Reduction Fund (ERF), which was set to
commence in 2014, has an annually fixed budget that is shared between firms that
abate pollution with larger abaters receiving larger shares of the fund. Our frame-
work, which models the sharing of rent according to relative efforts, may thus assist
in the analysis of the incentives underlying these recent policy developments.

Note that the interpretation of $P$ as a fixed value fund to finance abatement also
changes the informational requirements. While such fund can be sector specific (see
the NFFO), information on the industry would no longer be needed. Instead, given the more general framework of the ERF, monitoring and enforcing contractually-agreed abatement (but not output) suffices to implement the regulation.

2.7 Conclusion

The purpose of this chapter is to revisit some of the common criticisms of command-and-control policies by considering more modern forms of environmental standards. For example, benchmarking has often been discussed as a means to improve conventional environmental standards. This sort of mechanism has been advocated by a number of institutions such as UNEP and the World Bank (e.g. Ackermann et al. (1999)), but it has not yet been formalized. We fill this void by modeling the setting of environmental standards based on relative abatement efforts. Building on the theories of contests and yardstick competition, we develop a formal model of environmental standards stipulated via benchmarking and show that command-and-control regulation can both incentivize the adoption of advanced abatement technologies as well as eventually lead to the convergence of marginal abatement costs. Despite the possibility of providing overly strong incentives for abatement in the short run when investment in new technologies is not possible, we show that benchmarking regulation is more efficient than conventional standards as the former takes into account firms’ varying abatement costs. In addition, the problem of causing over-abatement in the short term is reduced when rent seeking is possible.

Our results, therefore, illustrate that the implementation of environmental standards based on benchmarking may provide a number of benefits to both the firms and the regulator as it not only accounts for firms’ varying efficiency in abating pollution but, unlike conventional command-and-control instruments, may also provide dynamic incentives to reduce emissions over time while reducing the social cost of abatement. Finally, as our discussion of the Australian ERF shows, the validity of our
results extends beyond the application to production standards and our framework has the potential to assist in the analysis of the most recent developments in climate policy when a fixed prize fund is used to incentivize emissions reductions.
2.A Mathematical appendix

Proof of Proposition 1

Proof. To solve (2.13) we derive the following set of first-order conditions:

\[
\frac{\partial \pi_i}{\partial c_i} = \frac{\mu P \left( \frac{3}{\mu I_i + \gamma_i} \right)^2}{4 \left( \frac{1}{\mu I_i + \gamma_i} \right)^3} - 1 = 0 \quad \text{for} \quad i, -i \in \Phi. \quad (2.34)
\]

Substitution of the first FOC into the second and some simplification yields

\[
\mu I_X + \gamma_X = \mu I_Y + \gamma_Y.
\]

As \( k_i = \frac{1}{\mu I_i + \gamma_i} \), it follows that

\[
k_X^* = k_Y^*. \quad (2.35)
\]

Substituting (2.35) into (2.34) yields the optimal level of investment:

\[
I_i^* = \frac{\mu P - 8\gamma_i}{8\mu}. \quad (2.36)
\]

As \( \frac{\partial^2 \pi_i}{\partial I_i^2} < 0 \), (2.36) indeed denotes a maximum.

With \( k_i = \frac{1}{\mu I_i + \gamma_i} \), (2.36) ultimately defines the cost parameter \( k_i^* = \frac{8}{\mu P} \). Finally, substituting (2.15) into (2.13) yields the corresponding payoff:

\[
\pi_i^* = \frac{P}{4} + \frac{\gamma_i}{\mu}.
\]

\qed
2.A Mathematical appendix

Proof of Proposition 2

Proof. The proof requires solving the game represented by Equation (2.17) via backward induction. The solution to the second stage is defined by the following first-order condition:

\[
\frac{\partial\pi_i}{\partial c_i} = \frac{Pqc^\frac{q}{q} - 1}{\sqrt{2\left(c_i^2k_X^2 + c_i^2k_Y^2\right)^2}} - 1 = 0.
\]

Equating both first-order conditions, we find \( c_i = c_{-i} \). Solving the game is then straightforward and yields:

\[
\tilde{a}_{i,q} = \sqrt{\frac{Pqk_i^q - 1}{2k_i^q + k_{-i}^q}} \quad (2.37)
\]

\[
\tilde{A}_q = \frac{\sqrt{Pqk_i^q}}{\sqrt{2k_i^qk_{-i}^q}} \left(\sqrt{k_i^q} + \sqrt{k_{-i}^q}\right), \quad (2.38)
\]

\[
\tilde{c}_{i,q} = \frac{Pqk_i^q}{2\left(k_{-i}^q + k_i^q\right)} \quad (2.39)
\]

\[
\tilde{C}_q = \frac{Pqk_i^q}{\left(k_{-i}^q + k_i^q\right)^{2}}, \quad (2.40)
\]

where \( k_i = k_i(I_i) = \frac{1}{\gamma_i + \mu I_i} \).

With the solution to the second stage defined by (2.37) to (2.40), the objective function reduces to (2.18). Equating the first-order conditions for \( X \) and \( Y \) yields

\[
\left(\frac{1}{\mu I_X + \gamma X}\right)^\frac{q}{2} \left(\frac{g + 2}{\mu I_X + \gamma X} + \frac{g - 2}{\mu I_Y + \gamma Y}\right) = \left(\frac{1}{\mu I_X + \gamma X}\right)^\frac{q}{2} \left(\frac{g - 2}{\mu I_X + \gamma X} + \frac{g + 2}{\mu I_Y + \gamma Y}\right),
\]

which implies

\[
\frac{1}{\gamma X + \mu I_X} = \frac{1}{\gamma Y + \mu I_Y}. \quad (2.41)
\]

To see this, note that there exists no \( \delta \neq 1 \) with \( \frac{1}{\gamma X + \mu I_X} = \delta \cdot \frac{1}{\gamma Y + \mu I_Y} \), for which the first-order condition holds. From (2.41) it directly follows that \( k_X = k_Y \).
With this finding, the equilibrium level of total abatement reduces to $\tilde{A}_q = \sqrt{\frac{Pq}{2k_X}}$ and first-best abatement is given by $A_1^* = \frac{\tilde{E}}{b + k_X}$. Equating $\tilde{A}_q$ and $A_1^*$, solving for $q^*$ is straightforward and results in (2.19).

Note that to ensure consistency of the mechanism’s abatement incentives, $q$ is constrained such that total abatement under benchmarking regulation, $\tilde{A}_q$, increases with higher levels of $q$; i.e., abatement incentives are consistent iff $\frac{\partial \tilde{A}_q}{\partial q} > 0$:

$$\frac{\partial \tilde{A}_q}{\partial q} = -\frac{P(\sqrt{k_X + k_Y})}{4\sqrt{2Pqk_Xk_Y}} \left( \frac{k_X}{\sigma k_X} \left( -2 + q \cdot \ln \left( \frac{k_X}{\sigma k_X} \right) \right) - k_Y \left( 2 + q \cdot \ln \left( \frac{k_Y}{k_Y} \right) \right) \right)$$

Hence, for $k_Y = \sigma \cdot k_X$, $\frac{\partial \tilde{A}_q}{\partial q} > 0$ iff

$$k_X^\frac{q}{k_X} \left( 2 - q \cdot \ln \left( \frac{k_X}{\sigma k_X} \right) \right) > (\sigma k_X)^\frac{q}{k_X} \left( -2 + q \cdot \ln \left( \frac{k_X}{\sigma k_X} \right) \right)$$

$$\iff \left( \frac{1}{\sigma} \right) ^\frac{q}{2} > \frac{q \cdot \ln(\sigma) - 2}{q \cdot \ln(\sigma) + 2}.$$}

A sufficient condition for the mechanism to yield consistent incentives to abate pollution is $q \cdot \ln(\sigma) - 2 < 0$ and thus $q < \frac{2}{\ln(\sigma)}$.  

Proof of Proposition 4

Proof. To derive Proposition 4, we proceed with an unconstrained optimization of (2.28)—where $k_Y = \sigma \cdot k_X$—and then derive conditions for potential corner solutions. The unconstrained optimization yields

$$\alpha^* = \frac{2\tilde{E}^2}{P\sqrt{\sigma k_X^2}} \left( -2 + \frac{b}{\sqrt{\sigma k_X^2}} + \frac{4\sqrt{\sigma}}{(1 + \sqrt{\sigma})^2} \right)^2.$$  

Hence, for $\tilde{E} > 0$, $\alpha^* > 0$, thus there is no corner solution at the lower bound of the domain of $\alpha$. It is also straightforward from (2.42) that a corner solution $\alpha^* = 1$
exists iff
\[ \bar{E} \geq \sqrt{P \cdot \Omega}, \]  \hspace{1cm} (2.43)

where
\[ \Omega = \frac{\sqrt{\sigma k_X^2}}{2} \left( -2 + \frac{b}{\sqrt{\sigma k_X^2}} + \frac{4\sqrt{\sigma}}{(1 + \sqrt{\sigma})^2} \right)^2. \]  \hspace{1cm} (2.44)

\section*{Proof of Proposition 5}

\textit{Proof}. To prove Proposition 5, we first show that for an interior solution of \( \alpha^* \), \( A(\alpha^*) > A^* \). For \( \alpha^* \in (0, 1) \), \( A(\alpha^*) < A^* \) iff

\[ \frac{\bar{E}(1 + \sigma)}{b + b\sigma + 2\sigma k_X} > \frac{\bar{E}}{\sqrt{\sigma k_X} \left( -2 + \frac{b}{\sqrt{\sigma k_X^2}} + \frac{4k_X\sqrt{\sigma}}{(\sqrt{\sigma k_X^2} + \sqrt{k_X^2})^2} \right)} \bigg|_{A(\alpha^*)}. \]  \hspace{1cm} (2.45)

Condition (2.45) simplifies to \( 1 < -\frac{(1 + \sigma)^2}{\sqrt{\sigma(1 + \sqrt{\sigma})^2}} \), which never holds. Hence, \( \forall \alpha^* \in (0, 1), A(\alpha^*) > A^* \).

Second, it is straightforward from (2.43) that \( \alpha^* = 1 \) iff \( \Omega \leq \frac{E^2}{P} \), where \( \Omega \) is defined in equation (2.32). Finally, from (2.12) we know that \( A(\alpha^* \mid \alpha^* = 1) < A^* \) iff \( \Psi < \frac{E^2}{P} \), where \( \Psi = \frac{(b\sigma + b + 2\sigma k_X)^2}{2k_X(1 + \sigma)^2 \sqrt{\sigma}} \). This completes the proof. \( \Box \)
2.B A generalized model with \( n \) agents

2.B.1 The maximization problem of the agents

For completeness, we show the results of the model with rent seeking in a generalized framework with \( i = 1, \ldots, n \) firms. For \( i \in \Phi \) and \( -i \in \Phi \setminus \{i\} \), the payoff function of the individual is

\[
\pi_i = \begin{cases} 
\left(\frac{\alpha}{m_i} + \frac{1}{c_i + \sum_{-i} c_i} \right) P - c_i - s_i \quad & \text{if } \max\{c_i, c_{-i}, s_i, s_{-i}\} > 0, \\
0 \quad & \text{otherwise.}
\end{cases}
\]

(2.46)

First- and second-order conditions allow us to solve for the individual and total equilibrium levels of abatement costs, abatement, and rent seeking.

The first derivative of the payoff function (2.46) with respect to \( c_i \) is given by

\[
\frac{\partial \pi_i}{\partial c_i} = \frac{\alpha P c_i^{-\frac{1}{2}} m_i \left( \sum_{-i} c_i^{\frac{1}{2}} m_{-i} \right)}{2 \left( c_i^{\frac{1}{2}} m_i + \sum_{-i} c_i^{\frac{1}{2}} m_{-i} \right)^2} - 1 = 0.
\]

As \( c_1 = c_2 = \ldots = c_i = \ldots = c_n \), we can calculate \( c_i \), which is given by

\[
\hat{c}_{i,n} = \frac{\alpha P m_i \left( \sum_{-i} m_{-i} \right)}{2 \left( m_i + \sum_{-i} m_{-i} \right)}.
\]

Total abatement costs \( C \) are simply given by \( \hat{C}_n = n \cdot \hat{c}_{i,n} = \sum_{i=1}^{n} \hat{a}_{i,n} k_i \).

As we have established that \( a_i = \left( \frac{c_i}{x_i} \right)^{\frac{1}{2}} \), we can easily compute individual and total abatement levels, i.e., \( \hat{a}_{i,n} \) and \( \hat{A}_n = \sum_{i=1}^{n} \hat{a}_{i,n} \).

The equilibrium level of rent seeking \( \hat{s}_{i,n} \) is derived by using the first-order condition of the payoff function with respect to \( s_i \):

\[
\frac{\partial \pi_i}{\partial s_i} = (1 - \alpha) P \frac{\sum_{-i} s_{-i}}{s_i + \left( \sum_{-i} s_{-i} \right)^2} - 1 = 0.
\]
2.B A generalized model with \( n \) agents

Given that \( s_1 = s_2 = \ldots = s_i = \ldots = s_n \), we have

\[
\hat{s}_{i,n} = \frac{(1 - \alpha)P(n - 1)}{n^2}.
\]

Aggregate rent seeking is given by the sum of the \( \hat{s}_{i,n} \): \( \hat{S}_n = \sum_{i=1}^{n} \hat{s}_{i,n} = n \cdot \hat{s}_{i,n} \).

To summarize, if payoffs are defined by (2.46), the equilibrium is defined by

\[
\begin{align*}
\hat{c}_{i,n} &= \frac{\alpha P \left( \sum_{-i} \frac{1}{\sqrt{k_{-i}}} \right)}{2 \sqrt{k_i} \left( \frac{1}{\sqrt{k_i}} + \sum_{-i} \frac{1}{\sqrt{k_{-i}}} \right)^{2}}, \\
\hat{c}_n &= \sum_{i=1}^{n} \frac{\alpha P \sum_{-i} \frac{1}{\sqrt{k_{-i}}}}{2 \sqrt{k_i} \left( \frac{1}{\sqrt{k_i}} + \sum_{-i} \frac{1}{\sqrt{k_{-i}}} \right)^{2}}, \\
\hat{a}_{i,n} &= \sqrt{\frac{\alpha P}{2} \sum_{i=1}^{n} \frac{\left( \sum_{-i} \frac{1}{\sqrt{k_{-i}}} \right)}{k_i^3 \left( \frac{1}{\sqrt{k_i}} + \sum_{-i} \frac{1}{\sqrt{k_{-i}}} \right)^{2}}}, \\
\hat{A}_n &= \sqrt{\frac{\alpha P}{2} \sum_{i=1}^{n} \frac{\left( \sum_{-i} \frac{1}{\sqrt{k_{-i}}} \right)}{k_i^3 \left( \frac{1}{\sqrt{k_i}} + \sum_{-i} \frac{1}{\sqrt{k_{-i}}} \right)^{2}}}, \\
\hat{s}_{i,n} &= \frac{(1 - \alpha)P(n - 1)}{n^2}, \\
\hat{S}_n &= \sum_{i=1}^{n} \hat{s}_{i,n} = n \cdot \hat{s}_{i,n} = \frac{(1 - \alpha)P(n - 1)}{n}.
\end{align*}
\]

2.B.2 Welfare optimization

We now determine the optimal \( \alpha_n \) by minimizing the costs to society:

\[
\min_{\alpha} \left[ D(\hat{A}_n) + \hat{c}_n + \hat{S}_n \right], \quad (2.47)
\]

s.t. \( 0 \leq \alpha \leq 1, \)
where

\[
D(\hat{A}_n) = \frac{1}{2b} \left( \hat{E} - \sqrt{\frac{\alpha P}{2}} \cdot \sum_{i=1}^{n} \left( \frac{1}{\sqrt{k_{i}}} \right) \right)^2
\]

\[
\hat{C}_n = \frac{\alpha P}{2} \sqrt{\hat{E}} \left( \frac{1}{\sqrt{k_{i}}} \right) \left( \frac{1}{\sqrt{k_{i}}} \right)
\]

\[
\hat{S}_n = \frac{(1 - \alpha) P(n - 1)}{n}
\]

Rearranging the first-order condition allows one to solve for the interior solution of the optimal \(\alpha\) in the \(n\)-player case:

\[
\alpha^*_n = \frac{2E^2 \left( \sum_{i=1}^{n} \left( \frac{1}{\sqrt{k_{i}}} \right) \right)^2}{P \left( -4 + \frac{4}{n} + b \left( \sum_{i=1}^{n} \left( \frac{1}{\sqrt{k_{i}}} \right) \right)^2 + 2 \sum_{i=1}^{n} \left( \frac{1}{\sqrt{k_{i}}} \right) \right)^2}
\]

It is easy to check that this is equivalent to the results of the case with two firms. Therefore, the underlying incentives remain unchanged.
Chapter 3

Environmental Policy Diffusion, Lobbying, and Market Structure

*joint work with Ian A. MacKenzie and Markus Ohndorf*

3.1 Introduction

Over the last few decades, there have been many instances in which one state (or substate entity) has adopted a particular environmental policy and other jurisdictions followed suit by implementing similar regulation. California’s vehicle emission standards of 1959 and its later amendments, which were subsequently adopted by many US states and served as a role model for regulation in Japan, the European Community, and South Korea, provides us with just one pertinent example (see Vogel, 1997a,b; Biedenkopf, 2012a). Whereas these policies concern product regulation, our focus is on the convergence of regulation restricting production externalities, such as the Czechoslovak Clean Air Act of 1991, which was predominantly based on German regulation. As a result, the Czechoslovak air pollution regulation largely adhered to the EU’s 1988 Large Combustion Plant Directive long before EU accession talks re-
quired such policy convergence (see Andonova, 2005). This kind of (decentralized) dissemination of stricter regulation to other countries (or states) is typically referred to as ‘policy diffusion’. To explain the existence of such policy diffusion, a number of reasons have been asserted: first, countries may adopt similar regulations as a consequence of cooperation or coercion. Second, countries may observe effective foreign regulation and decide to emulate such policies domestically. Although these explanations provide some understanding of the drivers of policy diffusion, they largely neglect important political aspects of the legislative process (see Biedenkopf, 2015). How do special interest groups impact regulation and, hence, the likelihood of policy diffusion? And what determines the level of the stakeholders’ lobbying efforts?

To answer these questions, we develop a political economy model that allows for the calculation of the likelihood of the legislator approving domestic environmental policy under the influence of political activity and in light of the stringency of foreign regulation. We hence assume that, initially, environmental policy exists in a foreign country but not domestically. In the domestic jurisdiction, the government (or some other eligible institution) then proposes environmental regulation and special interest groups expend effort in order to manipulate the chances of its legislative endorsement. Whether or not the proposed regulation is implemented, in which case policy diffusion occurs, crucially hinges on the lobby groups: taking into account their respective efforts, the legislator either approves or rejects the policy proposal. The pivotal role assigned to special interest groups reflects their considerable impact on the legislative process in most parliamentary systems, in which political competition among affected stakeholders precedes the implementation of virtually any regulatory measure.

Our political economy framework allows for the identification of conditions under which competing countries independently adopt stricter regulatory standards. We show that the interest groups’ political stakes, which depend on the stringency of reg-

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1Following Vogel (1997a), the literature occasionally also refers to a jurisdiction adopting the stricter regulation of its trading partners as ‘California effect’.
ulation in each of the two countries, define the probability of policy implementation in equilibrium. The elasticities of these stakes with respect to regulatory changes in turn determine whether the latter yield greater or lesser potential for policy diffusion to occur. By the use of quadratic and linear specifications of the damage function, we point out that the relative size of these elasticities depends on market parameters, in particular, the slopes of foreign supply and global demand. Given low relative slopes, tantamount to a low potential for domestic production, we also show that varying environmental vulnerability can yield contrasting effects: if foreign regulation is tightened, domestic output grows and, given a quadratic damage function, such change leads to an increase in the probability of policy diffusion. With linear environmental damage, on the other hand, the green lobby’s incentive to expend political effort is usually insufficient to countervail the brown lobby’s resistance to regulation. In this case, stricter foreign regulation can only increase the likelihood of policy diffusion if marginal damage is very large.

The key role of the relative slopes of supply and demand hints at the importance of market parameters for the diffusion of environmental policy. We, therefore, investigate and compare the probability of policy approval under perfect competition and different oligopolistic setups. While it may seem intuitive that an industrial leader is most likely to be able to spur the diffusion of regulation to follower countries, in fact, we find the opposite to be true: in a Stackelberg oligopoly, the potential for (partial) policy diffusion is larger if the country pioneering environmental regulation is the Stackelberg follower. Generally, it turns out that the probability of policy diffusion is greatest under perfect competition given that larger producer rents in oligopolistic markets amplify the industry’s resistance to domestic regulation.

Previous research has long established the importance of market structure for the effectiveness of environmental policy (see the collection of articles in Carraro et al., 1996). Building on the analysis of Buchanan (1969), who demonstrated the inefficiency
Environmental Policy Diffusion, Lobbying, and Market Structure

of Pigouvian taxation in industries with market power, Lee (1975) emphasized that effective pollution controls have to account not only for market power but also for the properties of the demand function, a key point in our analysis. An important finding in these studies is that regulation should typically be less stringent for price-setting firms so as not to inordinately reduce output. While Oates and Strassmann (1984) suggest that the inefficiencies of nondiscriminating policies are rather insubstantial, Lee (1975) raises another important point, namely, that discriminating policy schemes favoring firms with market power are difficult to justify in the political process. Whereas such regulation may, as Lee suggests, seem unjust, his concluding remark ignores the strong political influence exerted by firms with market power, which features prominently in the interpretation of our results.

To model the competition for political influence, we draw on the theory of contests (summarized by Konrad, 2009). The domestic policy proposal, which aims at limiting emissions from production, defines what is at stake for the relevant special interest groups: if implemented, the policy increases production costs and decreases profits while also reducing environmental damage. As a result, whereas the industrial lobby group opposes the introduction of such regulation, the environmental lobby group advocates it. Based on the contest model of Tullock (1980) and the notion that interest groups can influence yet not impose a legislative decision, we allow the lobbies’ political efforts to determine the proposal’s chances of implementation, i.e., our model establishes the probability of policy diffusion and we analyze the conditions that increase (or decrease) this probability. Indeed, despite industry groups frequently trying to impede the implementation of regulation, we often observe the diffusion of environmental policies even if they affect the competitive (dis-)advantage of a country’s producers. Recent examples of such regulatory convergence are China’s regulation of

Note that market structure also plays a crucial role in the contest literature on rent seeking, which our analysis is based on and which originally focused on the competition for market power and the ensuing rents (see Tullock, 1967).
3.1 Introduction

hazardous substances in electronics, which closely mirrors the EU’s RoHS directive, as well as policies adopted by South Korea to regulate chemicals in a similar fashion as the EU’s REACH regulation (see Biedenkopf, 2012b, 2013).\(^3\) Although, of course, other causes could underlie the diffusion of policy in these particular instances, our model offers a novel and important possible explanation: if the foreign country tightens its regulation, production shifts to the domestic industry, which increases local pollution and, hence, the efforts of the domestic environmental lobby. According to our model, the introduction of, for example, South Korea’s regulation of chemicals could thus be partly explained by the previous implementation of more stringent policies in the EU and the environmental consequences of the production shift that ensued (or the threat thereof).

The comparative politics literature on policy diffusion has identified numerous instances of regulatory convergence from eco-labeling to the promotion of renewable energy (see, e.g., Busch and Jörgens, 2005; Busch et al., 2005). These studies have also identified some of the major processes behind the diffusion of strict policies from pioneer countries to others.\(^4\) Coercion (e.g., the threat of (trade) sanctions) has been suggested as a possible cause as well as emulation or the sharing of best practices (see Oberthür and Tänzler, 2001). The implementation of environmental regulation can also be a requirement for broader cooperation as, for instance, membership in the EU presupposes a large degree of regulatory harmonization. Finally, the increasingly integrated global market has been highlighted as a potential driver of diffusion: if a good rather than its production is regulated and firms have to comply with environmental standards in one market, they may find it less burdensome to comply with similar

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\(^4\) The diffusion of regulation across jurisdictions has also been studied in the literature on environmental federalism (e.g., Oates, 2001; Revesz, 2001). This work, however, has mostly centered around the normative question of how the responsibility to regulate pollution is optimally shared among different levels of government and it has neglected political influence, an aspect that is vital to our analysis.
policies in other markets as well, which would reduce their opposition to regulation in the latter. Such political aspects of policy diffusion, however, have not been studied (see Biedenkopf, 2015). We seek to fill this void and are able to add another possible explanation for policy diffusion, namely, the pressure by special interest groups.

The important impact of lobby groups on environmental regulation in countries that compete on a global output market has been highlighted by the extensive research on the political economy of trade and the environment (surveyed by Sturm, 2003). In contrast to many studies in this field, which examine the effect of trade liberalization, we consider exogenous levels of competitiveness—which may be reduced by comparatively strict environmental policies—in order to focus on the strategic interaction between opposing interest groups and on the significant impact of foreign environmental regulation on their incentives to expend political effort. To the best of our knowledge, this study is the first to analyze political activity as a driver of environmental policy diffusion in open economies. Although Fredriksson (1997) starts with assumptions similar to ours, his focus is on the regulatory framework in one country only and he does not account for the strategic considerations induced by stricter policies abroad, which is pivotal to our interpretation. Conconi (2003) studies cooperative and noncooperative policies as well as the comparison between free and restricted trade while acknowledging the role of regulation in the other country. She concludes that policy coordination is more important under free trade. We, however, are able to show that even with free trade, unilateral regulation may suffice to lead to policy convergence in political equilibrium.

Our contribution is thus to provide a rigorous analysis of policy diffusion when the political economy of the legislator is taken into account. The political science literature has offered a number of potential explanations for policy diffusion, yet has focused mostly on multilateral approaches. We abstract from these causes and explain how policy diffusion can occur even if countries act unilaterally. To do so, we account
for the important but previously neglected role of interest groups in the regulatory process and show that political influence can offer yet another potential explanation for the convergence of environmental regulation.

The chapter is organized as follows: in Section 3.2, we develop our general model with two countries, where regulation is in place in the foreign country while two opposing lobby groups try to encourage or prevent the implementation of regulation in the home country. The industries of the two countries compete on a global output market. We derive the equilibrium and some general results. In Section 3.3, introducing fairly common assumptions regarding the shape of the demand and supply functions and considering a quadratic damage function, we demonstrate the potential of our framework to identify drivers of policy diffusion. Section 3.4 examines the effects of different market structures on policy diffusion given a linear environmental damage function. In Section 3.5, we endogenize the stringency of the policy proposal and allow the green lobby group to suggest the level of regulation. Section 3.6 concludes.

3.2 The model

3.2.1 Model setup

Consider a set of countries $J = \{h, a\}$ (home and abroad) that produce a homogeneous good for a global market. Production in country $j \in J$ is provided by a representative firm: firm $j$ in country $j$ can sell its output $x_j$—either domestically or internationally—at world price $p$. The world price is determined by the inverse global demand function $p(X)$, which is strictly decreasing and quasi-concave in total production, where

---

5Our model can be replicated with $|J| = n > 2$. The limitation to two countries may, however, be well-founded in the real world: country $a$ may represent the rest of the world in a competitive market or countries $h$ and $a$ may represent two major producers of the product in question. Our framework could then model, e.g., the impact of stricter pollution control in the EU on environmental regulation in China.

6Note that we abstract from complementary trade policies that would result in country-specific prices.
\(X = x_j + x_{-j}\) and \(-j \in J \setminus \{j\}\). Note that in a perfectly competitive market, production by firm \(j\) may be negligible compared to global output \(X\), thus, not affecting the world price. The production of \(x_j\) generates emissions, which cause local pollution. Country \(j\) can introduce environmental regulation to restrict these emissions and the regulatory stringency is captured by and increasing in parameter \(\tau_j \in [0, \infty)\). Our focus is on the policy choice in country \(h\) and we assume that foreign environmental regulation has been adopted at some level \(\tau_a > 0\). In the home country, the initial situation is one in which no regulation exists (i.e., \(\tau_h = 0\)). Now let \(\bar{\tau}_h\) denote the government’s proposed environmental regulation in country \(h\).\(^7\) The legislator’s policy options are then given by \(\tau_h \in \{0, \bar{\tau}_h\}\); i.e., the proposal is either approved or dismissed.

In our framework, once a regulatory standard has been proposed, special interest groups seek to sway the legislator in an effort to influence the probability of approval. This resembles many aspects of lobbying activity within parliamentary systems as lobbyists often have significant influence over the probability of a bill passing once it has entered the legislative process. We denote the set of special interest groups by \(\Lambda = \{B, G\}\). The brown (\(B\)) lobby, which represents the interests of the domestic firm, seeks to prevent more stringent regulation, whereas the green (\(G\)) lobby—representing environmentalists in the home country—supports the policy proposal. We model the political competition between the lobbies as a contest, which determines the probability of the government’s proposal being implemented. The timing of our model is as follows: first, the government in country \(h\) proposes some initial level of environmental regulation \(\bar{\tau}_h\).\(^8\) Second, following the policy proposal, special interest groups simultaneously invest in lobbying effort in order to alter the probability of the policy’s approval. Finally, following the decision by the legislator, i.e., after observing the

\(^7\)Note that \(\bar{\tau}_h\) could correspond to the exact stringency of \(\tau_a\) or it could be derived from an optimization by the regulator. In the latter case, however, the objective function of the regulator would have to be defined. Our results are more general and hold for any proposed level of \(\bar{\tau}_h\).

\(^8\)In Section 3.5, we extend our model to consider the particular case of a strategic proposal by the green lobby becoming the subject of the political contest.
current regulatory levels abroad and at home, firm $h$ competes on the global product market and payoffs for both lobbies ensue. We proceed with our analysis using backward induction and first derive the market equilibrium for any given level of $\tau_h$. This allows us to define the political stakes of the lobby groups, which we use to calculate the probability of a policy proposal being implemented.

### 3.2.2 The market equilibrium

Given the policy levels $\tau_h \in \{0, \tilde{\tau}_h\}$, which is determined via the political process, and $\tau_a$, the representative firm $j \in J$ selects output $x_j$ that maximizes its profit:

$$
\max_{x_j} \pi_j \left( x_j(\tau_j, \tau_{-j}), \tau_j \right) = x_j(\tau_j, \tau_{-j}) \cdot p \left( X(\tau_j, \tau_{-j}) \right) - c_j \left( x_j(\tau_j, \tau_{-j}), \tau_j \right). \tag{3.1}
$$

The profit of firm $j$ is a function of the production level and the stringency of domestic and foreign regulation. For firm $j$’s production cost we assume $\frac{\partial c_j}{\partial x_j} > 0$ and $\frac{\partial c_j}{\partial \tau_j} > 0$. Moreover, $\frac{\partial c_j(0)}{\partial \tau_j} < p(0)$ for all levels of $\tau_j$ to ensure positive levels of production in country $j$. Given that firms may pass (part of) the additional cost of regulation on to their customers, we assume $\frac{\partial p}{\partial \tau_j} \geq 0$ and $\frac{\partial p}{\partial \tau_{-j}} \geq 0$. Production is inversely related to the level of domestic regulation (i.e., $\frac{\partial x_j}{\partial \tau_j} < 0$), whereas stricter foreign regulation increases the domestic firm’s share of the global market, hence, $\frac{\partial x_j}{\partial \tau_{-j}} > 0$. As a result, stricter foreign regulation can affect firm $j$’s profit positively in two ways as it may increase the world price and it increases the amount produced in country $j$.

The latter, however, also has harmful effects for country $j$: as stricter foreign regulation increases domestic production, it also increases the amount of emissions and the ensuing environmental damage, which is denoted by $D_j \left( x_j(\tau_j, \tau_{-j}), \tau_j \right)$ with $\frac{\partial D_j}{\partial \tau_j} < 0$, $\frac{\partial D_j}{\partial x_j} > 0$ and $\frac{\partial^2 D_j}{\partial x_j^2} \geq 0$; i.e., it is decreasing in regulatory stringency and convex in the level of production.
3.2.3 The political equilibrium

Our main aim in this article is to investigate policy diffusion between countries, i.e., how environmental regulation of pollution in a foreign country—or a group of foreign countries—affects environmental policy domestically. Without loss of generality, let us focus on country $h$, the home country. Given the existence of foreign environmental policy, which we suppose has been set at an (average) stringency level $\tau_a > 0$, we analyze the effects on lobbying behavior and regulation in the domestic jurisdiction.

We denote by $\Gamma(\tau_h, \tau_a)$ and $\Pi(\tau_h, \tau_a)$ the payoff of the green and brown lobby groups, respectively, for both realizations of $\tau_h \in \{0, \tilde{\tau}_h\}$. The green lobby’s payoff is determined by

$$\Gamma(\tau_h, \tau_a) = -D_h(x_h(\tau_h, \tau_a), \tau_h)$$  \hspace{1cm} (3.2)

and, therefore, its relative stake in the lobbying process is given by

$$V_G = \Gamma(\tilde{\tau}_h, \tau_a) - \Gamma(0, \tau_a) > 0.$$  \hspace{1cm} (3.3)

Of course, the green lobby prefers more stringent regulation. The brown lobby, on the other hand, prefers no regulation, which results in the following political stake:

$$V_B = \Pi(0, \tau_a) - \Pi(\tilde{\tau}_h, \tau_a) > 0,$$  \hspace{1cm} (3.4)

where

$$\Pi(\tau_h, \tau_a) = \pi_h(x_h(\tau_h, \tau_a), \tau_h).$$  \hspace{1cm} (3.5)

We present the lobbying process as a Tullock contest in which interest groups invest sunk efforts to influence the probability of the policy’s legislative approval. The effort lobby group $\ell \in \Lambda$ expends in order to support or oppose the proposed policy is denoted $k_{\ell}$. The respective probabilities of the green and brown lobby to be successful
are dependent on their lobbying efforts relative to total outlays and given by:

\[
\rho_{\ell}(k_\ell, k_{-\ell}) = \begin{cases} 
\frac{k_r}{k_r + m r_{-\ell}} & \text{if } \max\{k_\ell, k_{-\ell}\} > 0, \\
\frac{1}{2} & \text{otherwise},
\end{cases}
\] (3.6)

where \(-\ell \in \Lambda \setminus \{\ell\}\), \(r\) measures the lobbies’ effectiveness in exerting political influence, and \(m\) represents the relative (dis-)advantage of group \(-\ell\) in the lobbying process.\(^9\) The probability of proposal \(\tilde{\tau}_h\) being approved is equivalent to the probability of success of the green lobby, \(\rho_G\), which—for ease of notation—we denote by \(\rho_G = \rho\) and, hence, \(\rho_B = 1 - \rho\). The lobbyists maximize their respective net expected payoffs given by

\[
\max_{k_G} E[\Gamma] = \rho \cdot \Gamma(\tilde{\tau}_h, \tau_a) + (1 - \rho) \cdot \Gamma(0, \tau_a) - k_G \quad \text{and} \\
\max_{k_B} E[\Pi] = (1 - \rho) \cdot \Pi(0, \tau_a) + \rho \cdot \Pi(\tilde{\tau}_h, \tau_a) - k_B.
\]

Using (3.2) to (3.5), the solution to this game is a pure strategy Nash equilibrium with optimal effort levels

\[
k^{\ast}_\ell = \frac{m r_{\ell} V^r_{\ell} + V^r_{-\ell}}{(V^r_{\ell} + m V^r_{-\ell})^2}.
\]

Substitution into (3.6) yields the equilibrium probability of \(\tilde{\tau}_h\)’s legislative approval, i.e.,

\[
\rho^{\ast} = \frac{V^r_G}{V^r_G + m V^r_B}. \quad (3.7)
\]

Given that we are interested in policy diffusion, our primary interest is in analyzing how \(\rho^{\ast}\) is influenced by foreign environmental policy \(\tau_a\). Note that, ceteris paribus, as stricter environmental policy abroad shifts production to country \(h\), it increases the efforts of both lobby groups. On the one hand, more domestic output increases the

\(^9\)See Epstein and Nitzan (2010) for an extensive analysis of this mechanism.
profit of the domestic industry thereby raising the stake of the brown lobby, on the
other hand, it increases local pollution and, hence, the support of the green lobby for
domestic regulation. Consequently, the ultimate effect of foreign regulation on \( \rho^* \) is,
a priori, unclear. Note also that policy diffusion, as defined here, may be incomplete
as the domestic policy proposal \( \tilde{\tau}_h \) can take any value that is lower than or equal to
\( \tau_d \). In contrast to foreign policy, higher levels of \( \tau_h \) reduce domestic output, which
also induces an increase in the respective stakes of both lobbies, again leaving the net
effect on \( \rho^* \) uncertain. In short, changes of the policy parameters, \( \tau_d \) and \( \tau_h \), induce a
change in \( \rho^* \) that depends on the relative losses or gains of each lobby group:

\[
\frac{\partial \rho^*}{\partial \tau_j} = \frac{m r (V_B V_G)^{r-1} \left( \frac{\partial V_G}{\partial \tau} V_B - \frac{\partial V_B}{\partial \tau} V_G \right)}{(V_G^r + m V_B^r)^2}, \tag{3.8}
\]

where \( j \in J \) and from which our first proposition directly follows:

**Proposition 1.** The equilibrium probability of policy diffusion, \( \rho^* \), is increasing in foreign or
domestic regulatory stringency if and only if

\[
\frac{\partial V_G}{\partial \tau} \frac{\partial V_G}{\partial \tau} > \frac{\partial V_B}{\partial \tau} \frac{\partial V_B}{\partial \tau}. \tag{3.9}
\]

Proposition 1 highlights the contentious political process preceding the implementa-
tion of environmental regulation. The probability of policy diffusion increases with
respect to domestic or foreign regulation only if the change of the green lobby’s stake
is greater than the shift of the brown lobby’s stake relative to their original levels. In
other words, for \( \rho^* \) to be increasing in \( \tau_j \), the elasticity of the green lobby’s rent with
respect to the policy variable has to be greater than the corresponding elasticity of the
brown lobby’s stake.

Note that the sign of (3.8) is independent of the contest parameters \( r \) and \( m \). Propo-
sition 1, hence, holds for any class of pure strategy Nash equilibria within a Tullock
3.3 A quadratic specification of environmental damage

Our qualitative conclusions from the following comparisons of different damage functions and market structures with respect to their effect on $\rho^*$ are, therefore, generally also independent of the parameters $r$ and $m$. To ease notation, for the remainder of this chapter, we thus assume $r = m = 1$, which reduces the probability of policy approval to

$$\rho^* = \frac{V_G}{V_G + V_H}. \quad (3.10)$$

### 3.3 A quadratic specification of environmental damage

In order to demonstrate the applicability of our results, we now specify the general forms of the previous section using fairly standard assumptions regarding the shape and characteristics of the demand, supply, and damage functions. We start our analysis supposing a perfectly competitive market such that global output $X$ is largely served by country $a$, which one may consider as representing the rest of the world. The cost function for each firm $j$ is given by

$$c_j(x_j(\tau_j, \tau_{-j}), \tau_j) = \frac{1}{2} \cdot \sigma_j \cdot x_j(\tau_j, \tau_{-j})^2 + \tau_j \cdot x_j(\tau_j, \tau_{-j}), \quad (3.11)$$

where countries differ with respect to $\sigma_j > 0$, a cost parameter denoting the available production technology. Environmental regulation leads to an upward shift of the supply curve, which would, for instance, be caused by the use of an additional input, the requirement of installing filter technology in the output (e.g., in vehicles), or the introduction of an emission tax. Aggregation of marginal cost curves yields a standard linear supply function and to characterize inverse demand, we also use a linear specification:

$$p(X(\tau_h, \tau_a)) = A - \alpha \cdot X(\tau_h, \tau_a), \quad (3.12)$$
where \( A > 0 \) and \( \alpha > 0 \). Assuming perfect competition, firm \( h \) has no direct influence on world price \( p(x_a) \). Consequently, equilibrium production levels and world price are given by

\[
x_a^* = \frac{A - \tau_a}{\sigma_a + \alpha}, \tag{3.13}
\]

\[
x_h^* = \frac{A\sigma_a + \alpha \tau_a - \tau_h(\sigma_a + \alpha)}{\sigma_h(\sigma_a + \alpha)}, \text{ and} \tag{3.14}
\]

\[
p^* = \frac{A\sigma_a + \alpha \tau_a}{\sigma_a + \alpha}, \tag{3.15}
\]

where \( \tau_h \in \{0, \tau_h\} \).

Given equilibrium price and quantities, it is straightforward to calculate firm \( h \)'s potential profit with and without regulation. By use of (3.4), the difference between the two defines the stake of the brown interest group within the political contest. It is given by

\[
V^Q_B = \frac{\tau_h(2A - \tau_h) + \alpha(2\tau_a - \tau_h)}{2\sigma_h(\sigma_a + \alpha)}, \tag{3.16}
\]

and is the main driver of the effort that the industrial lobby expends in order to increase the probability of proposal \( \tau_h \) being rejected by the legislator.

The other determinant, the stake of the green lobby, is driven by environmental damage in country \( h \), which we specify in this section as a quadratic function in output \( x_h \), i.e.,

\[
D_h(x_h(\tau_h, \tau_a), \tau_h) = (\omega - \tau_h) \cdot x_h(\tau_h, \tau_a)^2, \tag{3.17}
\]

where \( \omega > 0 \) is a parameter describing the vulnerability to environmental damage, which can be reduced by introducing an environmental policy \( \tau_h > 0 \). To rule out negative environmental damages, we presume \( \omega \geq \tau_h \). Note again that we consider pollution to be local, hence, there are no negative spillovers from production in country \( a \). Stepwise substitution of (3.17) into (3.2) and (3.3) for \( \tau_h \in \{0, \tau_h\} \) yields the
stake of the green lobby in country $h$:

$$V^Q_G = \frac{(\bar{\tau}_h - \omega) (\sigma_a A + \alpha \tau_a - \bar{\tau}_h (\alpha + \sigma_a))^2 + \omega (\sigma_a A + \alpha \tau_a)^2}{\sigma_h^2 (\alpha + \sigma_a)^2}.$$  \hspace{1cm} (3.18)

Given $V^Q_B$ and $V^Q_G$, the probability of policy proposal $\bar{\tau}_h$ being implemented is then determined by the political contest. Substituting (3.16) and (3.18) into (3.10) establishes the equilibrium probability of policy diffusion, which is denoted by $\rho^Q$:

$$\rho^Q = \frac{2(\omega(\alpha \tau_a + A \sigma_a)^2 - (\omega - \bar{\tau}_h)(\alpha \tau_a + A \sigma_a - \bar{\tau}_h (\sigma_a + \alpha))^2)}{2(\omega(\alpha \tau_a + A \sigma_a)^2 - (\omega - \bar{\tau}_h)(\alpha \tau_a + A \sigma_a - \bar{\tau}_h (\sigma_a + \alpha))^2 + \sigma_h \bar{\tau}_h (\sigma_a + \alpha)(2(\alpha \tau_a + A \sigma_a) - \bar{\tau}_h (\sigma_a + \alpha)))}.$$ \hspace{1cm} (3.19)

Further analysis of the causes of lobbying and its effect on $\rho^Q$ offers a number of insights regarding policy diffusion from country $a$ to country $h$. First, note that $\rho^Q$ is decreasing in $\sigma_h$ and $\lim_{\sigma_h \to 0} \rho^Q = 1$. If firm $h$ is very competitive in the production of good $x$, the legislator in country $h$ always approves regulation. Decreasing competitiveness of its producer, on the other hand, continuously reduces the probability of policy diffusion. Second, this probability is also decreasing in the stringency of the policy proposal itself, i.e., $\frac{\partial \rho^Q}{\partial \tau_a} < 0$. This can be explained in light of Proposition 1: for the specification at hand, the implementation of a more stringent policy causes a relative loss (reduced profit) to the brown lobby that is larger than the relative gain (environmental benefit) for the green lobby. As a result, ceteris paribus, more stringent policies are less likely to be implemented than those that are more lenient towards the producer. Third, however, a change of foreign regulation has the opposite effect, i.e., $\frac{\partial \rho^Q}{\partial \tau_a} > 0$. Stricter environmental policy abroad shifts production to the home country, which leads to higher profits for the domestic firm, yet given the polluter’s profit function is concave, it reduces its relative loss from domestic regulation. Furthermore, with a convex damage function, the rise in domestic production increases the stake of the green lobby at an increasing rate. As a result, the relative effect of more stringent foreign regulation on group $G$ is stronger than that on the brown lobby $B$ such that
the existence of (more stringent) foreign regulation makes domestic regulation and, therefore, policy diffusion more likely.

Intuitively, the probability of policy diffusion depends on both foreign regulation and the domestic proposal, yet the two exert countervailing effects. In our framework, there are two possible strategies to account for the influence of their interaction on policy diffusion: first, one could assume that the effect of foreign regulation is taken into account when the policy proposal \( \tilde{\tau}_h \) is drafted. We investigate such an endogenous policy proposal in Section 3.5. Alternatively, we can continue to consider the proposal as being exogenous, an approach that lends itself to a comparative static analysis, which offers additional insights. To do so, we adopt the general notion of policy diffusion as one country (partly) emulating the existing regulation of other countries such that we can express the stringency of domestic regulation as a share of the one implemented abroad:

\[
\tilde{\tau}_h = \kappa \cdot \tau_a,
\]

where \( \kappa \in (0, 1] \). This is consistent with, for example, a policy proposal that is oriented towards the (potentially stepwise) harmonization of environmental regulation. By the use of (3.19) and this relationship between \( \tilde{\tau}_h \) and \( \tau_a \), we obtain the following proposition:

**Proposition 2.** For nonnegative levels of production, the equilibrium probability of policy diffusion, \( \rho^Q \), changes with respect to the stringency of environmental regulation as follows:

\[
\begin{align*}
\frac{\partial \rho^Q}{\partial \tau_a} &> 0 \quad \text{iff} \quad \frac{\sigma_a}{\alpha} < (\geq) \mu^Q(\kappa), \\
\mu^Q(\kappa) &= \frac{\sqrt{\kappa \tau_a (\kappa \tau_a + 2A(6 - 5\kappa))} + A^2(2 - 3\kappa)^2 + \kappa(2\kappa - 3) \tau_a + A(2 - 3\kappa)}{2\kappa (3A - \kappa \tau_a)}.
\end{align*}
\]

Proposition 2 highlights the crucial role of the countries’ competition and their interaction on the world market in determining the likelihood of policy diffusion. This is underscored by the variant of the relative slopes criterion in (3.20): whether or not
policy diffusion occurs depends on the relative slopes of foreign supply and global
demand, $\frac{\sigma_a}{\alpha}$, which determine the amount $x_h$ produced in country $h$. If the ratio of the
slopes is large, policy diffusion is less likely given more stringent regulation abroad
(which here also implies a stricter proposal in country $h$). Such a large ratio suggests
a higher potential for domestic production as it could be driven by a large cost pa-
rameter $\sigma_a$, which indicates relatively little production in country $a$, or, for any given
$A$, by small $\alpha$, which is associated with relatively large overall demand. Domestic
production is further spurred by more stringent foreign regulation, but, given a suf-
ciently large level of initial domestic production as a result of large relative slopes,
such a change in $\tau_a$ leads to a greater relative loss for the brown lobby compared
to the relative gain of the green lobby and, hence, the likelihood of policy approval
decreases.

This effect is reversed for lower levels of $\frac{\sigma_a}{\alpha}$, which imply less domestic production.
In that case, (3.9) holds and the probability of (partial) policy diffusion ($\kappa < 1$) rises
with more stringent foreign regulation such that country $a$ may successfully assume
a leadership role and promote the adoption of environmental policy in country $h$.
Note, however, that independent of the relative slopes, full policy diffusion ($\kappa = 1$) is
unlikely as the derivative $\frac{\partial \mu^O}{\partial \sigma_a}$ is strictly smaller than 0 for $\mu^O(1)$.

3.4 The influence of market structure with linear damage

The importance of the relative slopes of supply and demand for our results hints
at the fact that the size and structure of the market are important determinants of
the probability of policy diffusion. We, therefore, proceed by comparing the case of
perfect competition with different oligopolistic settings. While the case of quadratic
environmental damage considered above yields analytical solutions for the different
market structures below, we opt for the use of a linear specification, which has the
additional advantage of providing insights into the role of the damage function and
its importance for condition (3.9). Nonetheless, this is mainly for the ease of representation as the results are similar but considerably more complex for the quadratic case. Throughout this section, we, hence, use a linear version of (3.17), i.e.,
\[
D_h(x_h(\tau_h, \tau_a), \tau_h) = (\omega - \tau_h) \cdot x_h(\tau_h, \tau_a). \tag{3.21}
\]

### 3.4.1 Perfect competition

Substitution of (3.21) into (3.2) and (3.3) yields the stake of the green lobby for linear environmental damage and perfect competition:

\[
V^{PC}_G = \frac{\tau_h(\sigma_a (A - \tau_h + \omega) + (\tau_a - \tau_h + \omega))}{\sigma_h (\sigma_a + \alpha)}. \tag{3.22}
\]

If the market is perfectly competitive, the stake of the brown lobby continues to be determined by (3.16). By the use of (3.16) and (3.22) in (3.10), the probability of policy diffusion for linear damages and perfect competition is given by
\[
\rho^{PC} = \frac{2}{4} \frac{(A\sigma_a + \alpha \tau_a + (\alpha + \sigma_a)(\omega - \tau_h))}{\tau_a (\sigma_a + A\sigma_a + (\alpha + \sigma_a)(2\omega - 3\tau_h))}. \tag{3.23}
\]

Note if \( x_h > 1 \), \( \rho^{PC} \) is smaller than \( \rho^Q \), the probability of approval in the case of quadratic environmental damage, because a convex damage function leads to the green lobby having a greater political stake and, thus, expending more effort in the contest, which leads to a larger probability of policy approval compared to the linear case.

Further differences between these cases are revealed when considering the derivatives of \( \rho^{PC} \) with respect to the policy variables. Note that for positive production levels and \( A > \omega \) (i.e., marginal damages that are not too large), the following holds:
\[
\frac{\partial \rho^{PC}}{\partial \tau_h} > (\leq) 0 \quad \text{iff} \quad \frac{\sigma_a}{\alpha} < (\geq) \frac{\omega - \tau_a}{A - \omega}. \tag{3.24}
\]
3.4 The influence of market structure with linear damage

Condition (3.24) again highlights the importance of the relative slopes of foreign supply and global demand for the adoption of domestic environmental policy. In contrast to the case of a quadratic environmental damage function for which the corresponding derivative is always negative, given the linear specification, \( \frac{\partial \rho_{PC}}{\partial \tau_h} \) can now be positive if the ratio of the slopes, \( \frac{\sigma_a}{\sigma_h} \), is relatively small. As argued above, this implies a comparatively low potential for domestic production such that, given the concave profit and linear damage functions, the relative rent loss of the domestic producer is smaller than the relative environmental benefit of policy approval and, therefore, (3.9) is fulfilled. As domestic output increases relative to the rest of the world, the marginal change in the political stake of the green interest group remains constant and positive, hence, \( V_G \) increases thereby reducing the relative effect of a change in \( x_h \) on the green lobby. At the same time, \( V_B \) grows at an increasing rate such that for sufficiently high levels of domestic production, the relative increase in the brown lobby’s resistance to stricter domestic regulation outweighs the corresponding relative change in effort by \( G \) and, hence, \( \rho_{PC} \) decreases in \( \tau_h \).

Another interesting insight is gained when considering foreign regulation. Again in contrast to the analogous derivative for the quadratic case, \( \frac{\partial \rho_{PC}}{\partial \tau_a} < 0 \): as stricter foreign regulation shifts demand from country \( a \) to country \( h \), it raises the industry’s political stake and spurs its opposition to \( \tilde{\tau}_h \). Given constant marginal environmental damage, however, the green lobby’s additional support for \( \tilde{\tau}_h \) is insufficient to countervail the relative increase in the brown lobby’s resistance and more stringent foreign regulation consequently decreases the probability of policy adoption in the home country.

Analogous to the analysis of the previous section, the interaction of the policy variables’ effects on \( \rho_{PC} \) is best dissected by using \( \tilde{\tau}_h = \kappa \cdot \tau_a \) with \( 0 < \kappa \leq 1 \) to rewrite (3.23):

\[
\rho_{PC} = \frac{2(\sigma_a(A + \omega - \kappa \tau_a) + \alpha(\omega + (1 - \kappa) \tau_a))}{\sigma_a(4A + 2\omega - 3\kappa \tau_a) + \alpha(2\omega + (4 - 3\kappa) \tau_a)},
\]  

(3.25)
Comparative static analysis yields the following proposition:

**Proposition 3.** For nonnegative levels of production, the equilibrium probability of policy diffusion, $\rho_{PC}$, changes with respect to the stringency of environmental regulation as follows:

For $A > \omega$:

$$\frac{\partial \rho_{PC}}{\partial \tau_a} < 0. \quad (3.26)$$

For $A < \omega$:

$$\frac{\partial \rho_{PC}}{\partial \tau_a} \geq 0 \quad \text{iff} \quad \frac{\sigma_a}{\alpha} > \left( \frac{\mu_{PC}(\kappa)}{\kappa(\omega - A)} \right), \quad (3.27)$$

where

$$\mu_{PC}(\kappa) = \frac{(2 - \kappa)\omega}{\kappa(\omega - A)}.$$

Given (3.21), marginal environmental damage is constant and, hence, the results of Proposition 3 are dependent on the relative size of $A$, the intercept of the demand function, and $\omega$, the slope of the damage function without policy intervention. If environmental damage does not exceed the consumer’s utility of consuming good $x$ (i.e., if $A > \omega$), as explained above, the probability of policy diffusion is strictly decreasing in the stringency of foreign regulation. This changes only if the damage to the environment is very large such that $A < \omega$, a case in which threshold $\mu_{PC}$ defines a lower limit for $\frac{\partial \rho_{PC}}{\partial \tau_a}$ to be positive. This result contrasts with our findings for the corresponding condition in the quadratic case, for which threshold $\mu^Q$ defines an upper limit for $\frac{\partial \rho^Q}{\partial \tau_a} > 0$. If the ratio of the slopes is small, i.e., if $\frac{\sigma_a}{\alpha} < \mu_{PC}$, domestic output $x_h$ is low. An increase in the stringency of foreign regulation allows for more domestic production and, given the firm’s concave profit function, this may entail considerable gains for the producer relative to its original level. The green lobby’s objective, on the other hand, is now linearly increasing in output, hence, a rise in $\tau_a$ spurs a relatively stronger reaction from the brown than from the green lobby if domestic output is low. The net effect of the lobbies’ relative reactions to a change in foreign regulation gradually changes as output increases: once $\frac{\sigma_a}{\alpha} > \mu_{PC}$, equivalent to a high production level $x_{hi}$, a very large damage parameter ($\omega > A$) causes the green lobby’s support to grow relatively more than the polluters’ resistance such that (3.9)
3.4 The influence of market structure with linear damage

is fulfilled and stricter foreign regulation increases the probability of policy diffusion.

Note that $\mu^{PC}(\kappa)$ decreases in $\kappa$ and for complete policy diffusion ($\kappa = 1$) reduces to

$$\mu^{PC}(1) = \frac{\omega}{A - \omega} < 0. \quad (3.28)$$

In that case, condition (3.27) is relaxed compared to partial policy diffusion. Note also that for $\omega > A$, $\rho^{PC}$ is unambiguously increasing in $\kappa$, hence, a proposal leading to full policy diffusion is more likely to be accepted than one favoring only partial diffusion.

3.4.2 Oligopolistic Stackelberg competition

Given the importance of the market parameters for the previous results, we now extend our analysis by investigating policy diffusion under oligopolistic settings. When there is Stackelberg competition, the question arises whether a quantity-setting leader can induce a higher probability of policy implementation in the follower country or vice versa. Considering the sequential choice of output levels, we have to distinguish between the potential roles of firm $h$ in the Stackelberg game: we denote by $L$ situations in which firm $h$ is the leader, whereas index $F$ indicates it being a Stackelberg follower. Given cost and inverse demand functions specified by (3.11) and (3.12), the equilibrium is characterized by

$$x_L = \frac{a(A - 2\tau_L + \tau_h) + \sigma_L(A - \tau_L)}{2\alpha(a + \sigma_L) + \sigma_L(2\alpha + \sigma_L)}, \quad \text{(3.29)}$$

$$x_F = \frac{\sigma_L(2\alpha + \sigma_L)(A - \tau_L) + \alpha(a(A - 3\tau_L + 2\tau_h) + \sigma_L(A - 2\tau_L + \tau_h))}{(2\alpha + \sigma_L)(2\alpha(a + \sigma_L) + \sigma_L(2\alpha + \sigma_L))}, \quad \text{and} \quad \text{(3.30)}$$

$$p^S = \frac{\sigma_L(2\alpha + \sigma_L)(a(A + \tau_h) + A\tau_h) + \alpha(a + \sigma_L)(a(A + 2\tau_L + \tau_h) + \sigma_L(A + \tau_L))}{(2\alpha + \sigma_L)(2\alpha(a + \sigma_L) + \sigma_L(2\alpha + \sigma_L))}, \quad \text{(3.31)}$$

where $L \in \{a, h\}$ and $F \in \{a, h\}$, depending on the role of country $h$ in the Stackelberg contest.

By the use of (3.29)-(3.31), it is straightforward to calculate the lobbies’ political stakes defined by (3.3) and (3.4) and here denoted $V^i_i$ where index $i \in \{L, F\}$. In
Environmental Policy Diffusion, Lobbying, and Market Structure

turn, this allows for the calculation of the probability of policy approval labeled $\rho^i$. Note that for the remainder of this section, we focus on the interaction effect of the regulatory levels at home and abroad and assume $\tau_a = \kappa \cdot \tau_a$. First, we determine the probability of policy diffusion for the case of country $h$ being a Stackelberg leader:

$$\rho^L = \frac{2 (\sigma_a (A - \kappa\tau_a + \omega) + a (A - 2\kappa\tau_a + \tau_a + 2\omega))}{\sigma_a (4A - 3\kappa\tau_a + 2\omega) + 2a (2 (A + \tau_a + \omega) - 3\kappa\tau_a)}.$$  \hspace{1cm} (3.32)

Analogous to our results for the case of perfect competition, with our linear specifications, $\rho^L$ is independent of the domestic cost parameter. Furthermore, as a result of the lower level of (domestic) production compared to the competitive market, policy diffusion is less likely when the home country is the Stackelberg leader than when it engages in perfect competition. To interpret this result, recall that the political stake of the green lobby is smaller for smaller levels of output while firm $h$ now enjoys market power, which allows for a larger profit, but may also entail a larger potential loss if domestic regulation is implemented. Given (3.10), by combining these two effects, $\rho^L < \rho^{PC}$ directly follows.

For country $h$ being the Stackelberg follower, the probability of policy approval is given by

$$\rho^F = \frac{1}{1 + \frac{1}{\sigma_a (2\kappa\tau_a + 2(2A - \kappa\tau_a + \omega)) (\sigma_a (2\kappa\tau_a + 2(2A - \kappa\tau_a + \omega)) + a (a (A + (2 - 3\kappa\tau_a + 3\omega)) + \omega (A + (1 - 2\kappa\tau_a + 2\omega)))}}. \hspace{1cm} (3.33)$$

As the Stackelberg follower always produces less than the leader, by the same logic as above, $\rho^F$ is, of course, smaller than $\rho^{PC}$. Furthermore, for the specifications at hand, country $a$ is more likely to be able to trigger policy diffusion to country $h$ if firm $a$ is the Stackelberg follower and firm $h$ chooses output first (i.e., $\rho^L > \rho^F$). In that case, the pressure by the environmental interest group in $h$ rises as well as the ability of the firm to absorb the cost of domestic regulation such that the probability of policy diffusion increases compared to a situation in which firm $h$ is the follower and country
3.4 The influence of market structure with linear damage

A assumes leadership in both environmental regulation and the Stackelberg game.

Next, we consider the effect of a marginal change in regulatory stringency on the probability of policy approval $\rho^i$. The findings we derive from this comparative static analysis are similar to our results for perfect competition and summarized in the following proposition, where $i \in \{L, F\}$ continues to denote country $h$’s role in the Stackelberg game:

**Proposition 4.** For nonnegative levels of production, the equilibrium probability of policy diffusion, $\rho^i$, changes with respect to the stringency of environmental regulation as follows:

For $A > \omega$:

$$\frac{\partial \rho^i}{\partial \tau_a} < 0. \quad (3.34)$$

For $A < \omega$:

$$\frac{\partial \rho^i}{\partial \tau_a} > (\leq) 0 \iff \frac{\sigma_a}{\alpha} > (\leq) \mu^i(\kappa), \quad (3.35)$$

where

$$\mu^L(\kappa) = \frac{A\kappa + 2(1 - \kappa)\omega}{\kappa (\omega - A)}, \text{ and}$$

$$\mu^F(\kappa) = \frac{A\kappa (\alpha + \sigma_h) + \omega (2(1 - \kappa)\sigma_h + \alpha(4 - 3\kappa))}{\kappa (\omega - A) (2\alpha + \sigma_h)}.$$

Similar to the case of perfect competition, an increase in the stringency of foreign environmental policy can only lead to an increase in the probability of domestic policy implementation if the pollution damage without regulation is significantly larger than the utility of consuming good $x$ (i.e., if $A < \omega$). If so, the sign of the effect of stricter regulation on $\rho^i$ again depends on the ratio of the slopes of demand and supply being larger or smaller than a threshold $\mu^i$. Note that $\mu^i < \mu^{PC}$, implying that the set of situations in which more stringent foreign regulation can raise the probability of policy diffusion is larger under a Stackelberg oligopoly than in a competitive market. Nonetheless, as stated before, Stackelberg competition is generally less likely to yield policy diffusion than perfect competition.
3.4.3 Cournot competition

When considering an oligopoly with simultaneous quantity choice, the analysis again yields similar results. After solving for the market equilibrium under Cournot competition, we derive the lobbies’ political stakes $V^C_B$ and $V^C_G$, which determine the corresponding probability of policy implementation $\rho^C$:

$$\rho^C = \frac{1}{1 + \frac{(\sigma_g + 2\alpha)(2\alpha + \sigma_h)(2A(\sigma_g + \alpha) - r_g(\alpha \sigma_g + 2\alpha(\kappa - 1)))}{2(\sigma_g(2\alpha + \sigma_h) + A(2\alpha + 2\sigma_h))((1 - 2\kappa)r_g + A + 2\omega) + \sigma_g(-\alpha \sigma_g + A + \omega))}. \quad (3.36)$$

Note that this probability is unambiguously smaller than under perfect competition. This is again a direct consequence of firm $h$ having market power and, therefore, output is smaller under Cournot competition, which decreases the political stake of the green lobby but may increase that of the brown lobby. We can, therefore, conclude that for all oligopolistic settings considered here, policy diffusion is less likely than under perfect competition. The following proposition summarizes the relative size of the probabilities for the different market structures, where $v \in \{PC, L, F, C\}$:

**Proposition 5.** The probability of policy diffusion varies with the degree of competition. Ceteris paribus, for any $\rho^v$ defined by (3.25), (3.32), (3.33), and (3.36), respectively, the following holds:

$$\rho^{PC} > \rho^L > \rho^C \leq \rho^F. \quad (3.37)$$

Comparing the likelihood of policy diffusion in oligopolistic markets shows that the most promising situation is one in which the first move in regulation is made by the Stackelberg follower. On the other hand, as the relative size of output produced by the Stackelberg follower and by Cournot competitors is ambiguous, political leadership in a Cournot market may or may not be more auspicious than a situation in which country $a$ pioneers environmental regulation and sets the level of output first.
3.5 An endogenous level of regulation

Our results up to this point hold for any proposed level of \( \tau_h \). This includes a proposal that minimizes social cost. For the case of linear environmental damage and perfect competition—characterized by (3.11)-(3.15) and (3.21)—the socially optimal policy level is given by

\[
\tau_h^* = \frac{\alpha (\sigma_h (\tau_a + A + 2\omega) + 3\alpha \omega) + \sigma_a (2\alpha \omega + (A + \omega)\sigma_h)}{\sigma_h (\sigma_a + 2\alpha)}. \tag{3.38}
\]

A priori, however, there is no reason for the proposal to be set at the optimal level as the policy proposer herself may be influenced by political interests. If the brown lobby were to propose regulation, of course, it would choose \( \tau_h^B = 0 \). A more interesting case arises if we assume that regulation is driven by the environmental lobby’s demand for policy intervention. In the extreme case, if the green lobby were able to submit a policy proposal \( \tau_h^G \), it would do so in anticipation of the ensuing political contest. It may, hence, be optimal for the green lobby not to propose regulation that is too demanding of the domestic firm as this decreases the chance of legislative approval. Regardless of its potential environmental benefit, a very strict policy proposal intensifies the industry’s opposition because, if approved, it would entail a significant increase in production cost. The optimal proposal from the perspective of the green lobby can be derived via backward induction as the level \( \tau_h^G \) that maximizes its expected net benefit:

\[
\max_{\tau_h^G} E[\Gamma(\tau_h^G)] = \rho(\tau_h^G) \cdot \Gamma(\tau_h^G, \tau_a) + \left(1 - \rho(\tau_h^G)\right) \cdot \Gamma(0, \tau_a) - k_G(\tau_h^G),
\]

where \( \rho(\tau_h^G) = \frac{V_G(\tau_h^G)}{V_G(\tau_h^G) + V_B(\tau_h^G)} \).

Solving this maximization problem for our case of linear environmental damage and perfect competition yields the following proposition:
Proposition 6. If the green lobby can decide on the stringency of the policy proposal, in
equilibrium, it proposes an environmental policy at the level

\[ \tilde{\tau}_G^h = \frac{13a\tau_a + 13A\sigma_a + 5(a + \sigma_a)\omega - \sqrt{(7(a\tau_a + A\sigma_a) - (a + \sigma_a)\omega)^2 + 24((a\tau_a + A\sigma_a)^2 - (a + \sigma_a)^2\omega^2)}}{12(a + \sigma_a)}. \]  
(3.39)

In the following, we assume that \( A \) is sufficiently larger than \( \omega \) to ensure that \( \tilde{\tau}_G^h \in \mathbb{R} \). Intuitively, \( \tilde{\tau}_G^h \) is increasing in the damage parameter \( \omega \). Note, however, that we rule out proposals that would over-internalize pollution damage such that \( \tilde{\tau}_G^h \) is constrained from above by the damage parameter (i.e., \( \tilde{\tau}_G^h \leq \omega \)). The strategic considerations and twofold objective of the green lobby are underscored by the fact that

\[ \text{if } \frac{\sigma_a}{\alpha} \geq \frac{\omega - \tau_a}{A - \omega} \Rightarrow \tilde{\tau}_G^h = \omega, \]

which again assigns an important role to the relative slopes of foreign supply and global demand. Note that this result also sheds more light on (3.24), which features the same condition. Whereas (3.24) implies that the probability of policy approval is decreasing in its stringency if the ratio of the slopes is larger than \( \Omega_1 \), in picking \( \tilde{\tau}_G^h \), the green lobby has to balance the likelihood of approval and the potential environmental benefit. For sufficiently large domestic production and consequent damage—as implied by a large ratio of the slopes—the green lobby, therefore, always proposes full internalization of environmental damage even at the cost of reducing the chances of implementation.

As our main focus is the potential for policy diffusion, the effect of foreign regulation \( \tau_a \) on the green policy proposal is of particular interest. We find that

\[ \frac{\partial \tilde{\tau}_G^h}{\partial \tau_a} \geq (0) \text{ iff } \frac{\sigma_a}{\alpha} \geq (0) \frac{39\sqrt{2}\omega(A - \tau_a) + 7\omega(\tau_a + A) - 73A\tau_a + 41\omega^2}{73A^2 - 14A\omega - 41\omega^2} \cdot \frac{1}{\Omega_2}. \]
In order to interpret this result, first note that $\Omega_1 > \Omega_2$ and that $\tau_a$ has no effect on $\tilde{\tau}_G^h$ if the ratio of the slopes exceeds $\Omega_1$. Second, recall that with linear environmental damage, the probability of policy implementation $\rho^{PC}$ is strictly decreasing in $\tau_a$. If domestic output is sufficiently (but not too) large—as defined by $\Omega_2 < \frac{\sigma}{\alpha} < \Omega_1$—the green lobby partly offsets this negative impact of foreign regulation on $\rho^{PC}$ by raising $\tilde{\tau}_G^h$, which increases both its potential benefit and its likelihood of approval. If, on the other hand, little is produced domestically—equivalent to a low ratio of the slopes—and, hence, pollution damage and the rent of the industry are small, the green interest group does not counteract the effect of $\tau_a$ on $\rho^{PC}$ as the expected marginal benefit of a more stringent proposal would be outweighed by its marginal cost.

Finally, notice that the green lobby’s policy proposal (3.39) could be smaller or larger than the socially optimal regulation and arbitrarily close. While the green lobby anticipates the industry’s effort in the political contest, it does not, as the social optimum requires, account explicitly for the relative competitiveness of the domestic firm specified by $\sigma^h$. As a result, if at all, $G$’s proposal only corresponds to the exact level of (3.38) by chance.

### 3.6 Conclusion

The purpose of this chapter is to provide a rigorous theoretical analysis of policy diffusion in a political economy context. To do so, we analyze the drivers of lobbying by special interest groups and their influence on the stringency of environmental regulation in an open economy. Notwithstanding that differences in countries’ regulatory standards give rise to concerns regarding their respective competitiveness, the diffusion of strict environmental policies from one sovereign state to others is commonplace. While some potential explanations have been offered, the literature has yet to study political influence as a prospective driver of such policy diffusion. This is despite the fact that the recent debate about a number of proposed trade agreements and
their possible effect on environmental regulation has highlighted the crucial role special interest groups play in regulatory convergence. Our political contest framework allows for the analysis of how their lobbying efforts, regulatory stringency, and ensuing output in one country are affected by a change in environmental policy abroad. We identify the degree of competition and environmental vulnerability as important determinants of the lobbies’ influence and, thus, the political equilibrium.

We begin our analysis by developing a general model of an open economy that is regulated by an independent, noncooperative government, which is influenced by two opposing lobby groups. Within this general framework, we investigate the consequences of (proposed) policy changes—both abroad and at home—for the likelihood of policy diffusion. We are able to identify the respective elasticities of the interest groups’ stakes with respect to a policy change as decisive determinants of the political equilibrium: policy diffusion becomes more likely if a marginal change in policy stringency yields a larger increase of the green lobby’s political stake relative to its original level than the corresponding relative change to the brown lobby’s objective.

In a second step, using varying functional forms, we identify circumstances under which competing countries are more (or less) likely to unilaterally adopt stricter regulation: in particular, we highlight the importance of both the extent of pollution damage and market structure in determining the potential for policy diffusion. Considering perfect competition, local pollution, and a convex environmental damage function, we find that stricter foreign regulation can improve the prospects for policy diffusion. As production shifts to the domestic market, its increasingly harmful effect on the environment yields a relative reaction of the green lobby sufficient to outweigh the industry’s response and, hence, a (foreign) country can increase the probability of policy diffusion by pioneering stringent environmental regulation.

3.6 Conclusion

This result contrasts our findings for a linear environmental damage function: in that case, only extreme levels of environmental vulnerability are able to stimulate lobbying by environmentalists that exceeds the marginal increase in the brown lobby’s opposition. Generally, however, a foreign country cannot trigger policy diffusion by increasing its own regulatory stringency because the constant marginal damage of output typically does not yield enough additional support for domestic regulation by the green lobby. If stricter regulation is proposed domestically, on the other hand, the corresponding extra effort by the environmental lobby may suffice to increase the likelihood of policy diffusion. This result, however, is contingent on a relatively small amount of domestic output, which, in turn, is the result of the ratio of the slopes of foreign supply and global demand being small. The latter could be caused by the foreign firm’s superior production technology or low overall demand.

Finally, to account for the importance of these market parameters, we consider cases of imperfect competition, which for many industries may be a more suitable description of real-world market structures. While the change in the degree of competition, of course, alters our results, our main qualitative findings with respect to marginal changes in the policy levels are very similar: in particular, only extraordinary levels of vulnerability to pollution in the home country may offer its trading partner(s) the opportunity to tighten its (their) regulation in order to enhance the chances of policy diffusion. It is worth highlighting, however, that the reduced output in consequence of imperfect competition allows for the (incomplete) ordering of market structures according to their potential to induce policy diffusion: we find that the latter is most likely in a country selling its output on a competitive market and least likely among Cournot competitors or Stackelberg followers. Among the imperfect market settings, policy diffusion is, hence, most likely in the country of the Stackelberg leader such that a foreign country reacting to the quantity choice of the home country holds the greatest promise as an environmental leader.
As the global economy is—with or without additional free trade agreements—becoming increasingly intertwined, understanding the interplay of environmental regulation and competitiveness is crucial. Both may trigger attempts to influence the level of regulatory stringency and, in this chapter, we have developed a comprehensible framework able to track some of the drivers of lobbying and their effect on the outcome of the political contest. Our results illustrate the complexity of the nexus between interest groups and legislative outcomes. As recently observed in the context of the proposed ‘Transatlantic Trade and Investment Partnership’ (TTIP) and the ‘Trans-Pacific Partnership’ (TPP), the public debate about trade, competitiveness, and the environment often seems simplistic and considering, among others, factors such as the market structure in different, affected industries would allow for a more detailed picture of the consequences and add depth to such discussions. Moreover, our general model of Section 3.2 is easily adapted to assist in potential future research seeking to identify further grounds for lobbying and to track its effect on regulatory outcomes. Such work could include, for example, an analysis of complementary trade policies and country-specific prices, strategic behavior by the regulator, economies of different sizes or the incentive structure of lobbies when pollution is transboundary, all of which may add insight into explaining the occurrence—or lack thereof—of policy diffusion.
Chapter 4

Emission Taxes, Lobbying, and Incomplete Enforcement

4.1 Introduction

Determining how best to enforce regulation is an important element of regulatory design and can pose considerable challenges for policy implementation. With limited monitoring capacities, governments cannot fully ensure that citizens adhere to all relevant rules and regulations. As a result, collusion, tax evasion, violations of health and safety standards, and misreporting of effluents or emissions, to name only a few examples, are commonplace. As environmental policies—the focus of this chapter—have become stricter over time, the incentives to evade them have increased accordingly, which has been the subject of the extensive literature on monitoring, enforcement, and compliance. At the same time, more restrictive policies have led lobby groups to redouble their efforts to influence the legislative process to align regulation as closely as possible with their own interests. The analysis of this competition for political influence has a long tradition in economics and, in particular, in environmental economics. In this chapter, I seek to complement previous research by combining these
two strands of the literature on regulation in order to analyze the interaction between incomplete enforcement and political competition. I integrate existing models in the respective fields to provide a novel analysis of the lobbying incentives of industrial and environmental interest groups that anticipate the inability of regulatory authorities to fully enforce environmental policies.

The main research question is thus how the lobbies’ efforts and the consequent political equilibrium are affected when interest groups know that regulation—once approved by the legislator—cannot be fully enforced. To answer this question, I develop a political economy model in which regulation to limit the emissions of an industrial process is proposed before the legislator, under the influence of both environmental and industry lobby groups, decides whether to endorse or reject the policy proposal. The lobbies’ relative efforts in the political contest, which depend on both the stringency and the enforceability of the proposed regulation, determine their respective prospects of success. If the environmental (industry) lobby succeeds, the proposal is (not) approved and regulation is (not) implemented. With the resulting regulatory framework in mind, the firm decides how much to produce and whether or not (or to what degree) to comply. Emissions and environmental damage ensue. I find that due to reduced opposition by the producers of the regulated good, counterintuitively, incomplete enforcement may actually reduce expected environmental damage compared to a situation in which an equally stringent policy could be fully enforced.

Unlike traditional political economy models, the framework in this chapter accounts for the fact that environmental policies are typically not perfectly enforceable. This has been analyzed for a variety of instruments and contexts (see, e.g., Harford, 1978, 1987; Sandmo, 2002; Macho-Stadler and Perez-Castrillo, 2006; MacKenzie and Ohndorf, 2012b). Heyes (2000) provides a comprehensive survey of the earlier literature. This literature, however, takes regulation as given and ignores the political
process preceding its implementation. Related to the analysis presented here are studies assuming that, if a violation of the law is detected, fines are contestable. This work was instigated by Kambhu (1989), who considers a regulatory standard and investigates compliance behavior of firms when they can challenge regulatory outcomes. His findings suggest that relaxing an environmental standard may increase the polluters’ abatement effort as fewer resources are spent on evading enforcement. Several authors have built on this work, including Nowell and Shogren (1994), who show that when fines for violations of regulation can be challenged, the traditional approach to strengthening enforceability by raising these fines or increasing monitoring efforts cannot assure a reduction of (illicit) pollution, but may instead only increase the effort to escape prosecution.

Underlying these analyses, however, is still the assumption that regulation is already in place. I, on the other hand, analyze contestability at an earlier stage and allow the industry (and an environmental lobby) to contest the implementation of the policy itself rather than challenging its outcome. The papers by Cheng and Lai (2012) and Ovaere et al. (2013), who—in contrast to this chapter—use the common-agency-model of Grossman and Helpman (1994), are closest to my framework. The analysis presented here, however, deviates from those studies in several important respects. Whereas Ovaere et al. (2013) analyze the influence of lobby groups on enforcement given an environmental standard, Cheng and Lai (2012) focus on lobbies’ influence on an emission tax rate given an exogenous enforcement policy. I, on the other hand, analyze the marginal impact of both enforcement and stringency parameters on the political equilibrium. In addition, Ovaere et al. (2013) consider a discrete compliance decision by the firms, i.e., to comply fully or not at all, whereas I allow for partial compliance by the firms as they decide on their optimal level of output, abatement, and reported emissions. The framework of Cheng and Lai (2012) accounts for these factors as well, yet they do not make the important distinction between short- and
long-term effects, whose differences are highlighted here.

In short, the model presented here accounts for the political competition preceding the introduction of new regulation and thereby assists in filling a significant gap in the literature on the political economy of environmental policy. The industry produces a good and, as a by-product, polluting emissions and regulation is proposed to limit this externality. The green lobby supports this proposal in order to reduce the adverse impact on the environment, whereas the industry, represented by the brown lobby, opposes it to avoid having to incur additional (compliance) costs. To model the political competition within the legislative process, I draw from the literature on contests. In particular, I use the lottery contest success function of Tullock (1980), which reflects the idea that interest groups can exert influence on the legislator but cannot impose a certain decision. Rather, the efforts of the lobbies determine the probability of their preferred policy being passed. Whereas political economy models of regulation typically assume full compliance if regulation is enacted, I allow for non-compliant behavior by the firm. To do so, I extend the firm’s decision set: it now has to decide not only on the profit-maximizing output but also on the optimal degree of regulatory compliance, which is determined by reported emissions and abatement effort. The compliance decision is driven by the potential fine for violations of the policy as well as by the likelihood of such violations being detected. The model of political competition presented here enables me to determine the probability of policy approval given the lobbies’ political efforts when enforcement is incomplete and it allows for the analysis of the factors that increase (or decrease) these efforts and the resulting probability of approval.

The framework I develop in this chapter contributes to the political economy literature on regulation as it combines the work on incomplete enforcement with that on political influence and thereby allows for a more realistic description of the regulatory process. To the best of my knowledge, this is one of the first analyses of the
interdependence of the firm’s effort to influence legislation and its compliance decision. In a setting with incomplete enforcement, the possibility of lowering compliance cost by, for example, misreporting its actual emissions can reduce the opposition of the industry to introduce regulation. I am able to show that, as a result, for the common specifications of the functional forms at hand, when an imperfectly enforceable emission tax is proposed, expected environmental damage is reduced compared to an equivalent, but fully enforceable policy proposal, which attracts stronger opposition. In other words, from an environmental perspective, some leniency in the enforcement of a policy may be desirable as it may significantly increase its chances of implementation.

The chapter is organized as follows: in Section 4.2, I develop the basic framework of political competition with incomplete enforcement. I describe the equilibrium and derive general results. Employing widely used functional forms in Section 4.3 and focusing on the short-term optimization of the firm, I demonstrate the applicability of the basic model. I derive explicit results in order to analyze the different drivers of the political equilibrium in the short term, which is determined not only by the stringency of the proposed regulation but also by its enforceability. Section 4.4 analyzes the firm’s long-term profit maximization—including its optimal choice of abatement technology—while Section 4.5 concludes.

4.2 The basic model

Consider a representative firm that produces and sells $x$ units of a good on a competitive output market at price $p$. The price is defined by inverse demand $p(x)$ and is strictly decreasing and quasi-concave in output produced. The production of the

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1One could think of many identical firms whose total number is normalized to one; alternatively, the representative firm could be an association of producers characterized by a similar cost structure. Each individual firm would then not be aware of its impact on the equilibrium price. Accordingly, I assume the market to be competitive and, therefore, the firm treats price $p$ as being exogenous.
good generates emissions \( e \) at a rate \( e = \frac{\phi}{\gamma} \cdot x \), which cause environmental damage. I refer to \( \phi > 0 \) as emission parameter and \( \gamma \geq 1 \) denotes an abatement technology, which could be prescribed by the regulator or, in the long run, could be chosen by the firm. Here, to curb pollution, an emission tax is proposed leaving the choice of abatement technology up to the firm. The stringency of the environmental policy is captured by parameter \( t \in [0, \infty) \) and is increasing in the latter. Initially, \( \gamma = 1 \), but by adopting an abatement technology \( \gamma > 1 \), in the long term, the firm is able to modify the production process in a way that reduces the rate of emissions, thereby reducing the firm’s tax burden or a possible fine. Whereas the status quo is a situation without regulation (i.e., \( t = 0 \)), assume now that regulation is proposed at some level \( \tau > 0 \). The legislator can either approve this proposal or reject it, therefore, its policy options are described by \( t \in \{0, \tau\} \).

Even if the policy is approved and implemented, in which case \( t = \tau \), the degree of its enforcement is what ultimately determines the level of compliance and, hence, its environmental benefit. If the firm is noncompliant but not exposed, it pays the emission tax on its reported level of emissions, \( z \), with \( 0 \leq z \leq e \). Let \( F(f, e, z) \) describe the penalty scheme as an increasing function of the degree of noncompliance and \( f \), a monetary unit measuring the severity of the fine, which typically exceeds the cost of compliance (i.e., \( f > \tau \)). In addition, let \( \mu \in [0, 1] \) denote the likelihood the representative firm assigns to it being caught if it violates the policy, which could, for instance, depend on the announced frequency of inspections. The proposed regulation is, therefore, fully described by \( \Psi = (\tau, \mu, F) \), where \( \tau \) measures the stringency of the proposal and \( \mu \) and \( F \) determine its enforceability.\(^3\)

\(^2\)Note that I follow, i.a., Stranlund et al. (2009) and consider the firm to be noncompliant if it misreports its emissions (i.e., if \( z < e \)). \( z \) (or equivalently \( e - z \)) measures the degree of the firm’s compliance. \(^3\)The stringency parameter \( \tau \) as well as the enforcement parameters \( \mu \) and \( f \) could be proposed at any level. If the objective of the regulator was clearly defined (e.g., to maximize welfare), the stringency and enforceability of the policy proposal could be derived from optimizing the corresponding objective function. The results presented here are more general and hold for any combination of proposed stringency and enforceability, i.e., I do not consider political competition over the exact level of the policy.
Having received information about the proposed environmental policy, special interest groups gauge the potential impact of the regulatory scheme on their respective objective and then try to sway the legislator in an attempt to manipulate the probability of approval. I consider a set of lobby groups \( I = \{B,G\} \). The interests of the industry are represented by a brown lobby \( B \) that opposes the approval and implementation of the policy proposal as that would increase the firm’s cost and lower its profit. A green lobby \( G \), which represents environmental interests, supports the proposed bill as it seeks to reduce the negative environmental impact caused by the production of \( x \). The legislative decision to approve or reject the proposed regulation is modeled as a contest, which determines the probability of the proposal being passed. In short, first, a policy scheme is proposed at some level of stringency \( \tau \) and enforceability \( \mu \) and \( F \). Next, the interest groups expend lobbying effort to alter the likelihood of this proposal being accepted by the legislator. Following the legislator’s decision, the firm observes the prevailing regulation and decides on its output \( x \) and level of compliance. The payoffs of the two interest groups—determined by profit and environmental damage, respectively—ensue. To derive the equilibrium probability of policy approval, which is a function of the lobbies’ efforts, I use backward induction. Hence, I first describe the market equilibrium, in particular, how to derive the equilibrium levels of output, abatement, and compliance, which I then use to calculate the political stake of each lobby.

### 4.2.1 Equilibrium production

Once the political contest has led to the implementation or rejection of the proposed regulatory scheme \( \Psi \), the firm decides on the profit-maximizing levels of output \( x \), compliance \( z \), and—in the long run—also abatement technology \( \gamma \):

\[
\max_{x,\gamma,z} \Pi = p \cdot x(\Psi) - C(x(\Psi),\gamma(\Psi),z(\Psi),\Psi).
\]
The firm’s profit $\Pi$ is a function of output, abatement, the stringency of the regulation but also its enforcement and the resulting level of compliance. I assume that output is inversely related to the stringency of regulation measured by $\tau$, i.e., $\frac{\partial x}{\partial \tau} < 0$. Total cost $C$ is given by the sum of production, abatement, and regulatory costs ($c_p$, $c_A$, and $c_R$, respectively):

$$C(\cdot) = c_p(x(\Psi)) + \lambda \cdot \left( c_A(x(\Psi), \gamma(\Psi)) + c_R(x(\Psi), \gamma(\Psi), z(\Psi), \Psi) \right),$$

where $\lambda = 1$ if the proposed policy is approved and $\lambda = 0$ otherwise. Total cost is assumed to be increasing in both output and the stringency of the policy, therefore, $\frac{\partial C}{\partial x} > 0$ and $\frac{\partial C}{\partial \tau} > 0$. While output as well as abatement effort increase abatement cost, $\frac{\partial c_A}{\partial x} \geq 0$ and $\frac{\partial c_A}{\partial \gamma} > 0$, the impact of the abatement technology on total cost may be ambiguous, i.e., $\frac{\partial C}{\partial \gamma} \not< 0$. Moreover, ensuring positive levels of output requires $\frac{\partial C(0)}{\partial \tau} < p(0) \forall \tau$. Given that the firm may be able to pass on (part of) the regulatory cost, the marginal impact of regulatory stringency on price $p$ is positive, i.e., $\frac{\partial p}{\partial \tau} \geq 0$.

Finally, as more output generates more emissions, which have an increasingly harmful effect on the environment, pollution damage—denoted $D(x(\Psi), \gamma(\Psi), \delta)$, where $\delta$ is a damage parameter—is assumed to be convex in the level of output (and emissions), i.e., $\frac{\partial D}{\partial x} > 0$ and $\frac{\partial^2 D}{\partial x^2} \geq 0$, and decreasing in abatement effort and regulatory stringency: $\frac{\partial D}{\partial \gamma} < 0$ and $\frac{\partial D}{\partial \tau} < 0$.

### 4.2.2 The political contest

The main objective of this chapter is to analyze the impact of a stricter, yet imperfectly enforced environmental policy on the lobbying behavior of the interest groups and the ensuing political equilibrium. The level of lobbying effort expended by an interest group is driven by its respective political stake. I denote the status quo payoffs of the brown and green lobby groups by $\Omega_U^B$ and $\Omega_U^G$, respectively. With subscript "U"
4.2 The basic model

denoting the equilibrium without regulation \((t = 0, \lambda = 0)\), they are given by

\[ \Omega^B_U = p_U \cdot x_U - c_p(x_U) = \Pi_U \quad \text{and} \quad \Omega^G_U = -D(x_U, \delta) = -D_U. \] (4.2)

(4.3)

The payoff of the brown lobby group is, hence, determined by the profit of the representative firm while the (negative) payoff of the green lobby group is equivalent to the environmental damage caused by the production of \(x_U\). If the proposed regulation is approved—indicated by subscript “R”—the new equilibrium and the lobbies’ payoffs are characterized by

\[ \Omega^B_R = p_R \cdot x_R - C(x_R, \tau_R, z_R, \Psi) = \Pi_R \quad \text{and} \quad \Omega^G_R = -D(x_R, \tau_R, \delta) = -D_R. \] (4.4)

(4.5)

where \(x_R, \tau_R, \) and \(z_R\) are all functions of \(\Psi\).

I can now define the political stake of lobby group \(i\), \(V_i\) with \(i \in I\), as the difference between its payoffs given group \(i\)'s preferred outcome and the subjectively worse equilibrium. Given that the green lobby prefers regulation to no regulation and the brown lobby’s preference is vice versa, the political stakes are given by

\[ V_B = \Omega^B_U - \Omega^B_R > 0 \quad \text{and} \quad \Omega^G_R - \Omega^G_U > 0. \] (4.6)

(4.7)

The political stake of the brown lobby is, therefore, simply given by the difference between the firm’s earnings with or without regulation. The political stake of the green lobby, on the other hand, is defined by the environmental damage avoided if the proposed emission tax is implemented.

The legislative process, which decides on the approval or rejection of \(\Psi\), is mod-
eled as a political contest in which lobby group $i$—depending on its stake in this contest—expends effort, denoted $k_i(V_i)$, to change the likelihood of the legislator’s endorsement of the policy. The lobbying effort of interest group $i$ relative to total lobbying expenditures—adjusted for a potential bias of the legislator—determines the probability of it being successful in the political competition. The group’s probability of success is given by

$$\rho_i(k_i, k_{-i}) = \begin{cases} \frac{k_i}{k_i + k_{-i} \omega_{-i}} & \text{if } \max\{k_i, k_{-i}\} > 0, \\ \frac{1}{2} & \text{otherwise,} \end{cases}$$

where $-i = I \setminus \{i\}$, parameter $r > 0$ determines the return on lobbying expenditure, and parameter $\omega_{-i} \geq 0$ represents a potential bias towards one lobby group or the other (if any).\(^4\) To simplify notation, for the remainder of this chapter I denote $\rho_G = \rho$ and $\rho_B = 1 - \rho$. The green lobby’s probability of success in the contest, $\rho = \frac{k_G}{k_G + k_B \omega_B}$, is, of course, equivalent to the probability of the proposed policy scheme $\Psi$ being approved by the legislator. Given their respective potential payoffs following the approval or rejection of the policy proposal, the interest groups choose the level of effort that maximizes their net expected payoffs:

$$\max_{k_i} E[\Omega_i] = \rho(k_i, k_{-i}) \cdot \Omega_R^i + (1 - \rho(k_i, k_{-i})) \cdot \Omega_U^i - k_i.$$

I denote the pure strategy Nash equilibrium that solves this game by $k_i^*$:

$$k_i^* = \frac{r \cdot V_i^{r+1} \cdot V_{-i}^r \cdot \omega_{-i}}{(V_i^r + V_{-i}^r \cdot \omega_{-i})^2},$$

where $V_i$ and $V_{-i}$ are determined in (4.6) and (4.7). Hence, $k_i^* > 0$ such that the

---

\(^4\)Both Konrad (2009) and Epstein and Nitzan (2010) provide an extensive analysis of this mechanism. $\omega_{-i}$ could also denote differences between the two groups’ efficiencies in lobbying.
4.2 The basic model

The equilibrium probability of policy approval defined in (4.8) can be rewritten as

\[ \rho^* = \frac{V_G'}{V_G + V_B' \cdot \omega_B}, \tag{4.10} \]

which is the green lobby group’s political stake relative to total political stakes and adjusted for the legislator’s potential bias. It is straightforward to show, however, that even if such bias exists, it does not affect the marginal impact of a more stringent policy proposal—or the impact of its stricter enforcement—on the equilibrium probability of policy approval. The derivative with respect to the policy parameters is given by

\[
\frac{\partial \rho^*}{\partial \theta} = \frac{r \cdot V_B^{-1} \cdot \omega_B \cdot V'_G \left( \frac{\partial V_G}{\partial \theta} V_B - \frac{\partial V_B}{\partial \theta} V_G \right)}{(V'_G + V'_B \cdot \omega_B)^2},
\]

where \( \theta \in \{\tau, \mu, f\} \). A more stringent policy proposal would be defined by a larger tax \( \tau \), whereas stricter enforcement is characterized by either more frequent inspections as represented by larger \( \mu \) or a larger monetary fine \( f \). Proposition 1 follows directly (see also Gerigk et al., 2015a):

**Proposition 1.** The equilibrium probability of policy approval, \( \rho^* \), increases in the stringency or enforceability of the proposed emission tax if and only if

\[
\frac{\partial V_G}{\partial \theta} V_G > \frac{\partial V_B}{\partial \theta} V_B. \tag{4.11}
\]

Intuitively, one might expect a stricter proposal to decrease the probability of its approval, yet this need not be the case. If the relative (positive) marginal environmental impact is greater than the relative (negative) marginal impact on profit, the green lobby increases its support relatively more than the brown lobby increases its opposition. As a result, the equilibrium probability of approval may increase.

Whether or not condition (4.11) holds, crucially depends on the effect of the policy parameters on the political stakes of the two interest groups. The firm’s profit and
environmental damage after implementation of the proposed emission tax, $\Pi_R$ and $D_R$, are functions of $\Psi$ and defined by (4.4) and (4.5), respectively. As $\Pi_U$ and $D_U$ are independent of the policy parameters, the marginal impact of the latter on the lobbies’ political stakes is given by $\frac{\partial V_B}{\partial \theta} = -\frac{\partial \Pi_R}{\partial \theta}$ and $\frac{\partial V_G}{\partial \theta} = -\frac{\partial D_R}{\partial \theta}$, respectively. Using the first-order conditions from the firm’s optimization problem to simplify notation, the marginal changes in the political stakes can be written as

$$\frac{\partial V_B}{\partial \theta} = \frac{\partial c_R}{\partial \theta} - x_R(\theta) \cdot \frac{\partial p_R}{\partial \theta} > 0 \quad \text{and} \quad \frac{\partial V_G}{\partial \theta} = -\left(\frac{\partial x_R}{\partial \theta} \cdot \frac{\partial D}{\partial x_R} + \frac{\partial \gamma_R}{\partial \theta} \cdot \frac{\partial D}{\partial \gamma_R}\right) \geq 0.$$ (4.12) (4.13)

Note that the respective political stake of either interest groups is (weakly) increasing in the policy parameters. The impact of a policy change on environmental damage may be transmitted via two channels as it could alter the quantity produced as well as the abatement technology. Both effects increase the stake of the green lobby. The two channels affecting the stake of the brown lobby, on the other hand, are countervailing: the implementation of a stricter environmental policy may raise the equilibrium price, which has a negative marginal impact on the brown lobby’s political stake, yet it also induces an increase of the firm’s cost, which raises the industry’s stake. Notwithstanding the potential price increase, the net effect of a stricter policy on the brown lobby’s stake is always positive, because—given the assumption of perfect competition—the firm’s cost increase always outweighs the additional marginal revenue. The more of the cost increase is offset by a concurrent price increase, however, the less effort can be expected from the brown lobby to oppose the policy approval. As a result, it is clear that, ceteris paribus, the stronger the price effect, the more likely it is for condition (4.11) to hold.
4.3 Compliance in the short term

I now apply common functional forms to the general framework of Section 4.2, initially assuming that the firm can only choose the levels of output and reported emissions. In the short term, however, it cannot change its production process to reduce actual emissions, hence, the firm is not able to adopt an abatement technology $\gamma > 1$ to lower its regulatory cost. This assumption is relaxed in Section 4.4. Moreover, as my objective is to single out the impact of the individual policy parameters on the political competition and equilibrium, I use the simplest plausible specifications for the demand and supply functions. Supply is determined by marginal cost, which I derive from $C^S (x(\Psi), z(\Psi), \Psi) = c_P(x) + \lambda \cdot c_R (x(\Psi), z(\Psi), \Psi)$, where superscript “$S$” denotes the short term and where production cost is given by

$$c_P (x(\Psi)) = \frac{\sigma \cdot x(\Psi)^2}{2}.$$  

Parameter $\sigma > 0$ characterizes the slope of the supply curve. As the firm is not able to modify the abatement technology (i.e., $\gamma = 1$), for a given level of output, it can only reduce a potential fine by reporting more truthfully. Regulatory cost is defined by

$$c_R (x, z, \Psi) = \tau \cdot z(\Psi) + \mu \cdot F(f, e, z) \quad \text{with} \quad F(f, e, z) = f \cdot (e(\Psi) - z(\Psi))^2. \quad (4.14)$$

Note that the penalty scheme is convex and, therefore, progressive in the degree of noncompliance.\(^5\) Marginal total cost yields the supply function and I assume inverse demand to be linear and given by

$$p(x(\Psi)) = A - \alpha \cdot x(\Psi). \quad (4.15)$$

\(^5\)This is a common assumption in the literature and used, e.g., in Harford (1978), Sandmo (2002), and Macho-Stadler and Perez-Castrillo (2006). Constant marginal fines typically lead to an all-or-nothing decision such that a firm either fully complies or does not comply at all. In that case, the enforcement parameters affect equilibrium regulation only at the threshold between compliance and noncompliance.
Recall, however, that the market is assumed to be competitive, hence, the representative firm does not influence the equilibrium price. Given the specifications above, one can compute the status quo market equilibrium as well as equilibrium production and price following the approval of the policy proposal. To ease the interpretation of the results and to focus on the effects of the stringency and enforcement parameters, let us assume for the remainder of this chapter that \( r = \omega_B = \alpha = \sigma = 1 \). Alternative specifications of the parameters are straightforward but do not change the qualitative findings.

### 4.3.1 Equilibrium on the output market without regulation

The preferred outcome of the industry is naturally the rejection of the policy proposal and the perpetuation of the status quo (\( t = 0, \lambda = 0 \)). In that case, \( C(x) = c_P(x) \) and maximization of (4.1) simply equates output price and marginal production cost. It is straightforward to show that the market equilibrium is then characterized by

\[
\begin{align*}
x_U &= \frac{A}{2} \\
p_U &= \frac{A}{2}.
\end{align*}
\]  

(4.16)  

(4.17)

If its output is not regulated, the representative firm, therefore, earns a profit of \( \Pi_U = \frac{A^2}{8} \). At the same time, \( e_U = \phi \cdot x_U \) emissions are generated, which cause environmental damage given by

\[
D_U = \frac{\delta \cdot e_U^2}{2} = \frac{A^2 \cdot \delta \cdot \phi^2}{8}.
\]  

(4.18)

\( D_U \) and \( \Pi_U \) are the respective payoffs of the interest groups given the status quo, which the green lobby \( G \) advocates to change and the brown lobby \( B \) seeks to maintain.
4.3 Compliance in the short term

4.3.2 Equilibrium on the regulated market

Now assume that a policy scheme \( \Psi = (\tau, \mu, F) \) has been proposed, where \( F \) is defined by (4.14). To decide on the level of their respective lobbying efforts, the interest groups have to anticipate the impact of the policy on the market equilibrium and the environment if it is approved. In the short term, the firm chooses output and reports emissions that maximize

\[
\max_{x,z} \Pi(x(\Psi), z(\Psi), \Psi) = p \cdot x - \left( \frac{x^2}{2c_p} + \frac{\tau \cdot z + \mu \cdot f \cdot (\phi x - z)^2}{c_R} \right). \tag{4.19}
\]

The necessary conditions allow me to derive the profit-maximizing levels of compliance and output, \( z^S_R \) and \( x^S_R \), and to determine the new equilibrium price, \( p^S_R \):

\[
x^S_R = \frac{A - \phi \tau}{2}, \tag{4.20}
\]

\[
z^S_R = \frac{1}{2} \left( \phi(A - \phi \tau) - \frac{\tau}{\mu f} \right), \tag{4.21}
\]

\[
p^S_R = \frac{A + \phi \tau}{2}. \tag{4.22}
\]

Note that for an interior solution with positive levels of production, demand has to be sufficiently large, i.e., \( A > \phi \tau \). Furthermore, \( z^S_R \) can be rewritten as \( z^S_R = \phi \cdot x^S_R - \frac{\tau}{2\mu f} \) and for this to be positive, \( f \geq \frac{\tau}{\mu \phi (A - \phi \tau)} \) has to hold. Throughout the rest of this chapter, I assume these conditions to be fulfilled.

4.3.3 The political contest

The equilibrium values (4.20)-(4.22) allow for the computation of the firm’s profit after policy approval as well as the environmental damage caused by the production of \( x^S_R \).

\[\text{Note that the Hessian matrix of the optimization problem defined by (4.19) is negative definite, which proves that } x^S_R \text{ and } z^S_R \text{ indeed define a maximum.}\]
They are given by

$$\Pi^S_R = \frac{1}{8} \left( (A - \phi \tau)^2 + \frac{2\tau^2}{\mu f} \right)$$

and

$$D^S_R = \frac{\delta \phi^2 (A - \phi \tau)^2}{8},$$

respectively. Calculating the political stakes of the two interest groups defined by equations (4.6) and (4.7) is then straightforward. The efforts of the lobbies, \(k_B\) and \(k_G\), are spurred by their stakes

$$V^S_B = \frac{\tau (\mu f \phi (2A - \phi \tau) - 2\tau)}{8\mu f}$$

and

$$V^S_G = \frac{\delta \phi^3 \tau (2A - \phi \tau)}{8}.$$ (4.23) (4.24)

In its general form, the equilibrium probability of the policy scheme being approved is defined by (4.10) and it is a function of the lobbies’ stakes in the political contest. By the use of (4.23) and (4.24), in equilibrium, the probability of approval for the specification above is thus given by

$$\rho^S = \frac{\delta \mu f \phi^3 (2A - \phi \tau)}{\mu f \phi (2A - \phi \tau)(\delta \phi^2 + 1) - 2\tau}.$$ (4.25)

The main aim of the analysis presented here is to investigate how the equilibrium is changed by a (marginal) change in the characteristics of the proposed policy. While the focus of much of the previous political economy literature has been on a stricter emission policy (here, a larger emission tax \(\tau\)), similar to Ovaere et al. (2013) and the works on contestable enforcement (e.g., Kambhu, 1989), I also analyze variations in the enforcement parameters—namely, the frequency of inspections \(\mu\) as well as larger fines \(f\). The impact of the policy parameters on the brown lobby’s political stake follow directly from (4.23) and confirm the general finding of Equation (4.12). Using \(\theta \in \{\tau, \mu, f\}\), they are summarized in Lemma 1:
4.3 Compliance in the short term

Lemma 1. A marginal increase in one of the parameters determining the stringency and enforceability of the proposed environmental regulation—$\tau$, $\mu$, and $f$—has a strictly positive effect on the political stake of the brown interest group:

$$\frac{\partial V^S_B}{\partial \theta} > 0.$$ 

Regardless of the policy parameter being reinforced, the expected profit of the industry decreases and, hence, the brown lobby’s stake increases. Equation (4.24) indicates that the situation is different for the green lobby; the reaction of its political stake to changes in the policy parameters is summarized by Lemma 2:

Lemma 2. A marginal increase in one of the parameters determining the stringency and enforceability of the proposed environmental regulation—$\tau$, $\mu$, and $f$—has the following effect on the political stake of the green interest group:

$$\frac{\partial V^S_G}{\partial \tau} > 0$$

and

$$\frac{\partial V^S_G}{\partial \mu} = \frac{\partial V^S_G}{\partial f} = 0.$$ 

While $\tau$ has the expected positive impact on the green lobby’s stake, as production $x^S_R$ is independent of $\mu$ and $f$, neither the probability of detecting noncompliance nor the level of the fine have an effect on environmental damage and, therefore, they have no effect on the stake of the green lobby. As a consequence, given their impact on the brown lobby’s stake, increases in the enforcement parameters should strictly decrease the equilibrium probability of policy approval. This intuition is confirmed by Corollary 1, which follows directly from the condition formulated in Proposition 1. On the other hand, the effect of an increase in $\tau$ on the equilibrium probability, $\rho^S$, is a priori unclear as both $V^S_B$ and $V^S_G$ are increasing in regulatory stringency. For the above specification, the net effect is summarized as follows:
Corollary 1. A change in the stringency of the proposed environmental regulation—equivalent to an increase in $\tau$—has a strictly positive effect on the equilibrium probability of policy approval, whereas increased enforceability—increases in $\mu$ or $f$—has the opposite effect:

\[
\frac{\partial \rho^s}{\partial \tau} > 0, \quad (4.26) \\
\frac{\partial \rho^s}{\partial \mu} < 0, \text{ and} \quad (4.27) \\
\frac{\partial \rho^s}{\partial f} < 0. \quad (4.28)
\]

One can conclude that if the level of the tax, $\tau$, is the driver of a stricter policy proposal, the likelihood of its implementation is strictly increasing as the green lobby’s reaction to such a change is relatively stronger than that of the brown lobby. In other words, the relative marginal environmental benefit of a more stringent proposal is strictly larger than the relative marginal increase of the cost to the producer. If, on the other hand, the driver of stricter regulation is one of the enforcement parameters, $\mu$ or $f$, this decreases the policy’s chance of legislative approval. For the policymaker this may then raise the question whether stricter enforcement of the policy can actually improve the environmental outcome or whether a higher, yet less strictly enforced emission tax yields greater environmental benefits.

4.3.4 Full vs. incomplete enforcement

If stricter enforcement of the proposed policy lowers the probability of its approval, clearly, there is an environmental trade-off to be made. Is it preferable, from an environmental point of view, to have weak enforcement of regulation but a high probability of it being passed? Or should a lot of effort be spent on enforcing the regulation (if implemented) at the cost of lowering its chance of legislative approval in the first place? To answer these questions, I now consider the extreme case of full enforcement, which is regarded here as being equivalent to strict regulatory abidance by the firm.
4.3 Compliance in the short term

(i.e., \( z = e \)).\(^7\) This is in line with the more traditional political economy literature on regulation, which typically assumes full compliance.

If the proposed emission tax, \( \tau \), can be fully enforced, the firm maximizes its profit by choosing the optimal level of production:

\[
\max_x \Pi(x(\tau), \tau) = p \cdot x - \frac{x^2}{2} - \tau \cdot \phi \cdot x.
\] (4.29)

In equilibrium, this leads to the same level of production as in a situation with incomplete enforcement, i.e., \( x^S_F = x^S_R \), where subscript “\( F \)” denotes the equilibrium with full enforcement. This is due to the strictness of enforcement only impacting the level of reported emissions, yet not the equilibrium output. Analogous to the calculations of previous sections, one can compute profit and environmental damage as well as the political stakes in the new equilibrium. The equilibrium probability of policy approval follows directly and is given by

\[
\rho^F_S = \frac{\delta \phi^2}{1 + \delta \phi^2}.
\] (4.30)

When comparing equilibrium probabilities of policy approval (4.30) and (4.25), it is straightforward to show that \( \rho^S > \rho^S_F \), which is in line with the finding of Corollary 1. From an environmental perspective, however, the extent of expected environmental damage under the two regimes is more informative. The two are compared in Proposition 2:

**Proposition 2.** Given a proposed level of the emission tax, \( \tau \), full enforceability of this policy proposal leads to strictly larger expected environmental damage compared to a situation with

\(^7\)Note that due to the convex penalty function, this is not equivalent to \( \mu = 1 \): even if the firm was sure to be discovered when misreporting its emissions, unless \( f \to \infty \), the firm would always deviate from truthful reporting by some (infinitesimally small) amount \( e - z > 0 \).
incomplete enforcement that would allow for the misreporting of emissions:

\[(1 - \rho_S^F) \cdot D_U + \rho_S^F \cdot D_{SF} > (1 - \rho_S^F) \cdot D_U + \rho_S \cdot D_{SR}^F.\]

**Proof.** From \(x_{SF}^F = x_{SR}^F\) it follows that \(D_{SF}^F = D_{SR}^F\). Above condition is then reduced to \(D_U > D_{SR}^F\), which always holds. \(\square\)

Despite the possibility of (partial) noncompliance by the industry, proposing an incomplete enforcement regime delivers strictly less expected environmental damage than the proposal of a policy regime with full enforcement. The possibility of violating the policy and misreporting its environmental impact reduces the industry’s opposition to the implementation of regulation. Similar to studies in which the enforceability itself is contestable, I find that starting from a situation with incomplete enforcement, counterintuitively, increasing the enforcement effort for an emission tax cannot deliver on the objective of the policymaker to decrease (expected) environmental damage. The proposal of policies that can be fully enforced always attracts too much opposition by the brown lobby to yield sufficient environmental benefits.

### 4.4 Compliance and abatement in the long term

When regulation is introduced that requires the firm to pay a tax on its emissions, a natural response of the firm might be to introduce measures to reduce its emission rate. Whereas the introduction of an abatement technology may not be feasible on short notice, in the medium to long term, the firm can adapt its production process to the new regulatory environment. To reduce the emission tax burden, the firm then has two decisions to make: it can still misreport its actual emissions \(z < e\), but it may now also modify production to lower the emissions per unit of output by adopting a new abatement technology \(\gamma > 1\). While misreporting reduces the amount of the tax paid by the firm, it increases the fine if the firm’s noncompliance is
exposed. Abatement, on the other hand, reduces both the tax to be paid as well as a potential fine, however, the firm, of course, has to incur the cost of implementing this technology. I assume that this cost depends on an abatement cost parameter $\eta$ and is increasing in both the efficiency of the technology measured by $\gamma$ as well as in output $x$. The profit maximization problem of the firm is then given by

$$\max_{x, \gamma, z} \Pi(x(\cdot), \gamma(\cdot), z(\cdot), \Psi) = px - \left( \frac{x^2}{2c_p} + \eta x(\gamma - 1) + \tau z + \mu f \left( \frac{\phi x}{\gamma} - z \right)^2 \right).$$

(4.31)

Inverse demand (4.15) and the first-order conditions determine the long-term equilibrium levels—denoted by superscript “$L$”—of production, abatement, reported emissions, and product price:

$$x_L = \frac{A + \eta - 2\sqrt{\eta \phi \tau}}{2},$$

(4.32)

$$\gamma_L = \sqrt{\frac{\phi \tau}{\eta}},$$

(4.33)

$$z_L = \frac{\mu f \sqrt{\eta \phi} (A + \eta - 2\sqrt{\eta \phi \tau}) - \tau^2}{2\mu f \sqrt{\tau}},$$ and

(4.34)

$$p_L = \frac{A - \eta + 2\sqrt{\eta \phi \tau}}{2}.$$ (4.35)

The ensuing environmental damage, $D_L$, and long-term profit of the firm, $\Pi_L$, follow directly. The differences between $\Pi^L_R (D^L_R)$ and $\Pi_U (D_U)$ determine the political stakes of the brown and green lobby groups given by

$$V^L_B = \frac{1}{2} \left( \frac{A^2}{4} - \frac{(A + \eta - 2\sqrt{\eta \phi \tau})^2}{4} - \frac{\tau^2}{2\mu f} \right)$$ and

$$\frac{\delta \phi}{8} \left( A^2 \phi - \eta (A + \eta - 2\sqrt{\eta \phi \tau}) \right).$$

(4.36)

(4.37)

The Hessian matrix of the optimization problem defined by (4.31) is negative definite, proving that $x^L_R$, $\gamma^L_R$, and $z^L_R$ define a profit maximum.
It is straightforward to show that the conclusions of Lemma 1 and 2 still hold, i.e., (the sign of) the different policy parameters’ marginal effect on the political stakes of the interest groups remains unchanged in the long term. As $V^I_L$ is—alogous to the results for the short term—independent of $\mu$ and $f$, of course, the conclusions of Corollary 1 regarding the enforcement parameters’ effect on the equilibrium probability of policy approval—now denoted $\rho^I_L$ and determined by (4.10), (4.36), and (4.37)—still hold, i.e., their marginal effect on the likelihood of legislative approval remains negative in the long term: $\frac{\partial \rho^I_L}{\partial \mu} < 0$ and $\frac{\partial \rho^I_L}{\partial f} < 0$. This highlights again the tradeoff between stricter enforcement and political feasibility, which underlies the result of Proposition 2. In fact, assuming that the proposed tax level is fully enforceable in the long term results—again analogous to my findings for the short term—in a strictly lower probability of legislative approval: $\rho^I_L > \rho^F_L$, where subscript “$F$” continues to denote full enforcement. As a result, the conclusion of Proposition 2 remains valid in the long term as the following corollary summarizes:

**Corollary 2.** In the long term, when the representative firm can lower its emission rate through the adoption of abatement technology, given a proposed level of the emission tax, $\tau$, full enforceability of this proposal results in strictly larger expected environmental damage compared to a situation with incomplete enforcement that would allow for the misreporting of emissions:

$$
(1 - \rho^F_L) \cdot D_U + \rho^F_L \cdot D^L_F > (1 - \rho^I_L) \cdot D_U + \rho^I_L \cdot D^L_R.
$$

(4.38)

Full enforcement of the proposed tax continues to be harmful in the long term if the objective is to reduce expected environmental damage. By allowing the firms some leeway in the reporting of their emissions, the policymaker can increase the chances of policy approval considerably and thereby lower expected environmental damage.

When it comes to changes in the third policy parameter, $\tau$, on the other hand, its marginal impact on the equilibrium probability of policy approval is notably different in the long term and no longer unambiguous. This is summarized in Proposition 3:
Proposition 3. In the long term, provided a given level of enforceability, a marginal increase of the proposed emission tax, \( \tau \), has the following effect on the equilibrium probability of legislative approval \( \rho^L \):

\[
\frac{\partial \rho^L}{\partial \tau} \begin{cases} 
> 0 & \text{if } \Lambda_1 < \delta < \Lambda_2, \\
\geq 0 & \text{otherwise,}
\end{cases}
\]

where \( \Lambda_1 \) and \( \Lambda_2 \) are defined in Appendix 4.A.

Proof. \( \Lambda_1 < \delta \iff \frac{\partial V^L_G}{\partial \tau} > \frac{\partial V^L_B}{\partial \tau} \) and \( \Lambda_2 > \delta \iff V^L_B > V^L_G \). If both inequalities hold, condition (4.11) is always satisfied. For more details, see Appendix 4.A.

In the long term, the level of the emission tax, \( \tau \), affects the level of production, the firm’s reporting of emissions, and, importantly, its abatement effort. These have varying and to some extent opposing impacts on the lobbying of the two interest groups such that the marginal effect of a higher emission tax on its probability of legislative approval is typically ambiguous. It is possible, however, to use Proposition 1 to define a sufficient condition for an unambiguously positive effect of \( \tau \) on \( \rho^L \):

if the damage parameter \( \delta \) is large enough (relative to other parameters) such that \( \frac{\partial V^L_G}{\partial \tau} > \frac{\partial V^L_B}{\partial \tau} \), yet not too large to ensure that \( V^L_B > V^L_G \), the relative marginal reaction of the green lobby to changes in the tax rate always outweighs that of the brown lobby and the probability of policy approval \( \rho^L \) is increasing in the policy proposal’s stringency. Note the ambiguous impact of the damage parameter, \( \delta \), here: whereas it does not affect the brown lobby, it strictly increases both the stake of the green lobby as well as its marginal reaction to a change in the proposed tax level. Ultimately, it is the change in the stakes of the lobby groups, \( V^L_B \) and \( V^L_G \), relative to their original levels that determines the equilibrium effect of \( \tau \). For sufficiently large levels of \( \delta \), \( V^L_G > V^L_B \) and the sufficient condition is no longer met, hence, the sign of the marginal effect of \( \tau \) on \( \rho^L \) is uncertain.

In short, while an increase in the enforcement parameters, \( \mu \) and \( f \), continues to reduce the probability of policy approval in the long run, the long-term effect of an
increase in the stringency parameter $\tau$ is ambiguous: different elements of the firm’s reaction to such an increase—consisting of lower production, lower emissions, and more abatement effort—may have opposing effects on the interest groups’ lobbying efforts, therefore, rendering an unequivocal policy recommendation impossible.

4.5 Discussion and conclusion

The purpose of this chapter is to analyze the strategic behavior of special interest groups and their impact on regulation when the latter is not fully enforced. Although the influence of lobbies has been studied extensively in the political economy literature, incomplete enforcement has been widely neglected in these studies. Nevertheless, one often observes that firms or individuals, knowing that violations may not be detected, do not (fully) comply with regulation limiting their legal set of actions. Whereas this may occasionally be due to ignorance, conscious and strategic disregard of regulations seems, more often than not, to be the underlying driver of these violations. In a model with a representative firm whose emissions may or may not be taxed, I study the political contest between brown and green interest groups when they anticipate the incomplete enforceability of the proposed tax and the consequent level of tax evasion. This study, therefore, contributes to and expands the literature on the political economy of regulation as it is one of the first analyses in this field to account for the incomplete enforcement of the policy in question.

To do so, I first develop a general model of political competition between brown and green interest groups, which is based on Tullock’s (1980) policy contest framework. An important conclusion from the analysis of the general model is that the relative intensity of the reactions by the lobby groups to changes in the model parameters drives the political equilibrium, namely, the probability of policy approval: if the brown (green) lobby is most affected by a marginal increase in one of the parameters, the probability of approval decreases (increases). Although I focus on the
4.5 Discussion and conclusion

policy parameters, these results would equally hold for parameters characterizing, for example, environmental damage, demand, or supply. Next, I specify the model with common functional forms and find that the policy’s proposed stringency, captured by the level of $\tau$, has a positive marginal effect on the probability of policy approval in the short term. This is due to the level of the tax having a relatively stronger effect on the green lobby’s political stake than on that of the industry. The latter can pass on part of the regulatory cost to the consumer or it could decide to reduce its tax burden by misreporting its emissions. On the other hand, pushing for tighter enforcement of the policy—either by conducting more frequent inspections or by increasing the potential fine—may be detrimental to the objective of lowering pollution as it decreases the chance of legislative approval both in the short and long term. In these cases, the brown lobby is more affected and increases its effort in the legislative process accordingly. These results are in line with the findings of Kambhu (1989); Heyes (1994); Garvie and Keeler (1994) and Cheng and Lai (2012), who demonstrate that the impact of more frequent inspections may be counterintuitive and ambiguous at best. To conclude, full enforcement of a proposed emission tax may actually lower its expected environmental benefit and the regulator may be better off allowing for some degree of infringement.

Very similar interpretations would also hold for regulation based on tradable pollution allowances, a policy that the model presented here is easily adapted to. Assuming that polluters are price-takers on the allowance market, the cost of each (reported) unit of emissions is then determined by the price of tradable emission permits, whereas noncompliance is measured by the difference between actual emissions and the number of allowances obtained by the polluter. Note that although grandfathering would reduce the producer’s real compliance cost, a profit-maximizing firm would nonetheless account for the opportunity cost of the allowances such that above model and the conclusions it provides would still apply in such a setting.
As pollution of various kinds is causing severe environmental damage, locally as well as globally, governments around the globe have responded by tightening environmental regulation. This has been accompanied not only by a rising incentive for noncompliance but also by political pressure from both the industry as well as from environmentalists trying to influence the legislative process. An analysis of this political competition without accounting for the need to enforce proposed regulation is just as incomplete as the analysis of imperfect regulatory enforcement without considering the political process preceding the regulation’s implementation. In this chapter, I have developed a model that allows for the analysis of the interaction between the two and that, therefore, provides a more realistic picture of the world than previous models. I illustrate the important distinction between the stringency of the policy and the strictness of its enforcement, both of which motivate the level of effort by the lobby groups but may have opposing effects on the political equilibrium. Finally, the applicability of the framework developed here is, of course, not limited to an emission tax (and emissions trading), but may be equally appropriate in the context of other environmental policy instruments as well as safety regulation, health standards, and the like.
4.A Mathematical Appendix

Proof of Proposition 3

Rewriting equations (4.36) and (4.37) yields

\[ V^L_B = \frac{1}{2} \left( x^2_U - \left( x^1_R \right)^2 - \frac{\tau^2}{2\mu} \right) \quad \text{and} \quad (4.39) \]

\[ V^L_G = \frac{1}{2} \delta \phi^2 \left( x^2_U - \left( \frac{x^1_R}{\gamma^1_R} \right)^2 \right) \quad , \quad (4.40) \]

where \( x^1_R \) and \( \gamma^1_R \) are defined by (4.32) and (4.33), respectively, and \( x_U \) is defined by (4.16). By use of condition (4.11), the following holds:

\[ \text{if} \quad \frac{\partial V^L_G}{\partial \tau} > \frac{\partial V^L_B}{\partial \tau} \land V^L_B > V^L_G \Rightarrow \frac{\partial \rho^L}{\partial \tau} > 0. \]

Differentiation of (4.39) and (4.40) with respect to \( \tau \) yields

\[ \frac{\partial V^L_B}{\partial \tau} = -x^1_R \cdot \frac{\partial x^1_R}{\partial \tau} - \frac{\tau}{2\mu} \quad \text{and} \quad (4.41) \]

\[ \frac{\partial V^L_G}{\partial \tau} = \frac{\delta \phi^2 \left( x^1_R \cdot \frac{\partial \gamma^1_R}{\partial \tau} - \gamma^1_R \cdot \frac{\partial x^1_R}{\partial \tau} \right)}{(\gamma^1_R)^3}. \quad (4.42) \]

By comparison of (4.39) and (4.40) as well as (4.41) and (4.42), the following holds:

\[ \delta > \frac{-(\gamma^1_R)^3 \cdot \left( 2\mu f x^1_R \frac{\partial x^1_R}{\partial \tau} + \tau \right)}{2\mu f \phi^2 x^1_R \left( x^1_R \cdot \frac{\partial \gamma^1_R}{\partial \tau} - \gamma^1_R \cdot \frac{\partial x^1_R}{\partial \tau} \right)} \Rightarrow \frac{\partial V^L_G}{\partial \tau} > \frac{\partial V^L_B}{\partial \tau} \quad \text{and} \quad \Lambda_1 \]

\[ \delta < \frac{(\gamma^1_R)^2 \left( 2\mu f \left( x^1_R \right)^2 - x^2_U \right) + \tau^2}{2\mu f \phi^2 \left( x^1_R \right)^2 - (\gamma^1_R)^2 x^2_U} \Rightarrow V^L_B > V^L_G. \quad \Lambda_2 \]

Using the equilibrium values (4.16), (4.32), and (4.33), one can show that \( \Lambda_2 > \Lambda_1 \).

One can then define the following three intervals:

1. \( \delta > \Lambda_2 > \Lambda_1 \Rightarrow V^L_G > V^L_B \land \frac{\partial V^L_G}{\partial \tau} > \frac{\partial V^L_B}{\partial \tau} \Rightarrow \frac{\partial \rho^L}{\partial \tau} \geq 0, \)

One Mathematical Appendix

Proof of Proposition 3

Rewriting equations (4.36) and (4.37) yields

\[ V^L_B = \frac{1}{2} \left( x^2_U - \left( x^1_R \right)^2 - \frac{\tau^2}{2\mu} \right) \quad \text{and} \quad (4.39) \]

\[ V^L_G = \frac{1}{2} \delta \phi^2 \left( x^2_U - \left( \frac{x^1_R}{\gamma^1_R} \right)^2 \right) \quad , \quad (4.40) \]

where \( x^1_R \) and \( \gamma^1_R \) are defined by (4.32) and (4.33), respectively, and \( x_U \) is defined by (4.16). By use of condition (4.11), the following holds:

\[ \text{if} \quad \frac{\partial V^L_G}{\partial \tau} > \frac{\partial V^L_B}{\partial \tau} \land V^L_B > V^L_G \Rightarrow \frac{\partial \rho^L}{\partial \tau} > 0. \]

Differentiation of (4.39) and (4.40) with respect to \( \tau \) yields

\[ \frac{\partial V^L_B}{\partial \tau} = -x^1_R \cdot \frac{\partial x^1_R}{\partial \tau} - \frac{\tau}{2\mu} \quad \text{and} \quad (4.41) \]

\[ \frac{\partial V^L_G}{\partial \tau} = \frac{\delta \phi^2 \left( x^1_R \cdot \frac{\partial \gamma^1_R}{\partial \tau} - \gamma^1_R \cdot \frac{\partial x^1_R}{\partial \tau} \right)}{(\gamma^1_R)^3}. \quad (4.42) \]

By comparison of (4.39) and (4.40) as well as (4.41) and (4.42), the following holds:

\[ \delta > \frac{-(\gamma^1_R)^3 \cdot \left( 2\mu f x^1_R \frac{\partial x^1_R}{\partial \tau} + \tau \right)}{2\mu f \phi^2 x^1_R \left( x^1_R \cdot \frac{\partial \gamma^1_R}{\partial \tau} - \gamma^1_R \cdot \frac{\partial x^1_R}{\partial \tau} \right)} \Rightarrow \frac{\partial V^L_G}{\partial \tau} > \frac{\partial V^L_B}{\partial \tau} \quad \text{and} \quad \Lambda_1 \]

\[ \delta < \frac{(\gamma^1_R)^2 \left( 2\mu f \left( x^1_R \right)^2 - x^2_U \right) + \tau^2}{2\mu f \phi^2 \left( x^1_R \right)^2 - (\gamma^1_R)^2 x^2_U} \Rightarrow V^L_B > V^L_G. \quad \Lambda_2 \]

Using the equilibrium values (4.16), (4.32), and (4.33), one can show that \( \Lambda_2 > \Lambda_1 \).

One can then define the following three intervals:

1. \( \delta > \Lambda_2 > \Lambda_1 \Rightarrow V^L_G > V^L_B \land \frac{\partial V^L_G}{\partial \tau} > \frac{\partial V^L_B}{\partial \tau} \Rightarrow \frac{\partial \rho^L}{\partial \tau} \geq 0, \)
2. $\Lambda_2 > \delta > \Lambda_1 \implies V_B^L > V_C^L \land \frac{\partial V_B^L}{\partial \tau} > \frac{\partial V_C^L}{\partial \tau} \implies \frac{\partial \rho^L}{\partial \tau} > 0$, and

3. $\Lambda_2 > \Lambda_1 > \delta \implies V_B^L > V_C^L \land \frac{\partial V_B^L}{\partial \tau} > \frac{\partial V_C^L}{\partial \tau} \implies \frac{\partial \rho^L}{\partial \tau} \geq 0$.

Proposition 3 directly follows.
Chapter 5

Conclusion

In light of the deteriorating state of the global environment, which is regularly assessed, for instance, by the United Nations Environment Programme (see UNEP, 2012b, for the most recent report), curbing the emissions of pollutants is imperative. Due to their significant contribution to total emissions, reducing the discharge of pollutants from industrial production processes is particularly important and at the center of the analysis presented in this thesis. Environmental economists have long identified the most efficient policy instruments to achieve this objective, yet environmental regulation is rarely stringent enough nor does it typically provide efficient incentives for producers to abate pollution. The often-observed inefficiency of real-world regulation has frequently been attributed to the predominant use of command-and-control instruments as well as to the considerable influence of private interests. This thesis set out to further the understanding of both command-and-control regulation and the political influence and competition that typically determines environmental policy. The goal was to revisit several apparently evident characteristics of different regulatory instruments in light of, first, the potential of benchmarking to improve the performance of environmental standards and, second, special interest groups’ power to shape the political process and the resulting regulation. More specifically, we sought to answer
the following research questions:

(1.A) Can the inclusion of relative performance mechanisms in command-and-control regulation improve the effectiveness and efficiency of environmental standards?

(1.B) How do special interest groups affect the efficiency of environmental standards stipulated via benchmarking?

(2) Under which circumstances can an environmental interest group successfully lobby for the diffusion of environmental policy and under which circumstances can an industrial lobby group prevent it?

(3) What is the impact of a proposed policy’s incomplete enforceability on the strategic behavior of the interest groups and the probability of the proposal’s approval?

Section 5.1 summarizes our answers to above questions and lays out how they, individually and as a whole, contribute to the literature on environmental regulation. To derive these answers, we adapted the public policy contest model proposed by Tullock (1980) in which two competing interest groups—seeking to protect the environment and to minimize producers’ regulatory cost, respectively—try to alter the probability of the legislator approving and implementing a given environmental policy. The model we devised is well suited to analyze lobbying in the context of environmental regulation and it can be applied well beyond the settings of the previous chapters. Potential extensions are the subject of Section 5.2, which outlines how future research could build on the work presented here, before Section 5.3 reflects on the findings more broadly and reviews the relevance of the research at hand for policy and policymaking.

Our analysis mostly ignored the possibility of lobby groups influencing the level of the proposed regulation itself, but instead focused on the lobbying of the legislator given a predefined stringency (and enforceability) of the policy proposal. This assumption could be relaxed in future work (see Section 5.2).
5.1 Findings and contribution to research

The original contribution of this thesis is twofold: first, we rationalized the use of relative performance mechanisms in environmental policy and developed the first formal model of benchmarking regulation. Second, we analyzed lobbying by special interest groups in three distinct and salient regulatory settings and identified the lobbies’ motives and their impact on the regulatory outcome. Hence, we were not only able to assist in understanding and improving modern regulatory tools, but we also highlighted how and why lobby groups seek to influence the design of these instruments and environmental regulation more generally.

Previous research in the field of industrial organization has long established the efficiency gains of regulation based on the regulatees’ average performance compared to conventional regulation. We adapted this insight to the regulation of environmental externalities as we sought to answer the first research question regarding the potential amendment of environmental standards through the use of relative performance mechanisms. In particular, we provided a novel analysis of one specific relative performance mechanism (i.e., benchmarking) and confirmed the view that the latter allows emission targets to be met at lower cost. We concluded that stipulating environmental standards via benchmarking could yield significant efficiency gains relative to conventional standards that usually prescribe the same abatement level or technology to all polluters. In addition, we showed that benchmarking—by inducing competition in emission abatement—can provide strong incentives to innovate and, therefore, offers dynamic incentives to abate pollution that are absent from traditional command-and-control regulation. Our results suggest that relative performance mechanisms based on the (average) abatement effort of the regulated firms may provide policymakers with a promising alternative to market-based policies but also with a viable way to improve the effectiveness of regulation where the use of command-and-control policies still prevails.
Whereas the answer to the first research question adds to the emerging literature on relative performance mechanisms in environmental policy, the focus of this thesis and of the remaining research questions was to contribute to understanding the role of the political interaction between legislators and lobby groups in the determination of environmental regulation. Underlying this work was the idea that special interest groups seek to exert influence on the legislator’s decision by advocating their respective views on the political, environmental, and economic tradeoffs related to the policy’s approval. In the case of benchmarking regulation, one such tradeoff is its potential to provide—from an economic perspective—inefficiently strong incentives to abate pollution, which would afford environmental benefits at an excessive cost to the producer. As a result, in examining the impact of interest groups on benchmarking regulation (research question 1.B), we demonstrated the impact of such influence on regulation and welfare to be ambiguous. If relative performance mechanisms produce overly strong incentives to reduce emissions, political influence has the potential to provide an efficiency-enhancing effect on (second-best) regulation.

Next, in addressing research question 2, we analyzed the role of interest groups in the convergence of environmental policy. Our political economy framework enabled us to fill a void in the literature on policy diffusion by providing the first rigorous, theoretical assessment of the political factors underlying the diffusion of environmental regulation. When regulated firms face competition on a global output market, foreign environmental regulation typically plays a crucial role in establishing the competitiveness of domestic firms and, as a result, is an essential driver of their (degree of) opposition to the introduction of domestic regulation. We identified key determinants of brown and green lobby groups’ efforts—and, hence, of the probability of policy convergence—and how they affect the interdependence of foreign and domestic regulation. Our model assigned pivotal roles to the type of pollutant and, more importantly, market structure and the ensuing degree of competition in resolving the
political contest that determines the lobbies’ respective chances of being successful and whether or not policy diffusion occurs in equilibrium. Unlike previous research, which mostly considered different multilateral approaches to explain policy convergence, we, therefore, were able to provide an explanation of policy diffusion based on unilateral action and domestic factors. In doing so, we extended the research both on policy diffusion as well as on market structure and environmental policy, neither of which has given much consideration to the influence of special interest groups.

Finally, there has been a tendency in the political economy literature to disregard potential violations of the legal restrictions that regulated firms are subjected to. We sought to contribute to filling this gap by answering research question 3, that is, by analyzing how incomplete enforceability affects the political equilibrium. Chapter 4 built upon existing studies on monitoring and enforcement in order to explore the effect that the anticipated inability of the regulator to fully enforce an environmental tax may have on the behavior of special interest groups. Whereas monitoring and potential fines affect the reporting of emissions by the regulated industry (i.e., its degree of compliance with the policy), its output may be independent of these factors. We showed that, as a result, the political stake of environmentalists—which naturally depends on real and not reported emissions—may be unaffected by incomplete enforceability. We elaborated how the latter changes the probability of policy approval in equilibrium and why the opportunity to misreport emissions can decrease the opposition to proposed regulation and thereby increase its expected environmental benefits. We, hence, assisted in the understanding of lobby groups’ behavior when faced with incomplete enforceability, but, as we devised one of the first political economy models accounting for noncompliance, we also provided a framework that allows future research to analyze this important aspect of reality in various other settings, for example, given different functional specifications of the market characteristics or the objectives of green and brown interest groups.
To sum up, the key contributions of Chapters 2-4 are in two fields as they add to the literature on environmental regulation, first, by considering the use of relative performance mechanisms and, second, by accounting for the political competition behind regulatory decisions. The next section points out how the framework used to study the political contest lends itself to a wider range of applications in environmental policy analysis and it discusses some of the potential extensions.

5.2 Outlook: potential pathways for future research

Chapters 2-4 cast new light on the impact of political competition between lobby groups on the determination of environmental policy. To focus on the parameters at issue—as with any other economic model—our analytical framework was based on a number of assumptions and our results are restricted by the model specifications. This realization, however, need not necessarily be seen as a mere limitation but also as an opportunity for future work. Although one cannot easily draw conclusions about the validity of our results in other policy settings, our contest framework offers the required tools to study even very different regulatory measures in depth. Future research could, hence, build upon the insights of this thesis in at least two ways, first, by extending the existing analyses and, second, by using the policy contest model to explore alternative regulatory environments. Some examples of possible routes for future work are summarized in Table 5.1 and discussed in some detail below.

Extensions of the analyses at hand could include (1) endogenizing previously exogenous parameters, (2) examining additional exogenous parameters or changes to the existing ones, and, finally, (3) trying to verify some of the results empirically. Throughout most of our analysis, the policy proposal is viewed as exogenous, yet in Chapter 3 we explore the idea of a green interest group proposing a level of regulation and demonstrate the possibility of endogenizing the stringency of the proposal. Alternatively, in recognizing the importance of lobby groups’ influence on the political
5.2 Outlook: potential pathways for future research

<table>
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Table 5.1: Examples of potential future work

equilibrium, the regulator could choose the stringency of the proposed policy strategically by anticipating its impact on the lobbies’ efforts (see Section 5.3). These efforts as well as the likelihood of a policy’s approval are driven by the tradeoff between business profits and environmental benefits and, therefore, any fully considered proposal should try to find the (subjectively) optimal balance between the two. Doing so, however, would, similar to the common-agency model of the political process, require a predefined objective function of the regulator that accounts for its potential preference for one stakeholder’s objective over the other’s. Such analysis could offer a novel perspective of the strategic considerations—not only of the interest groups but, importantly, also those of the regulator—underlying the determination of environmental policy. This extension could be particularly interesting in the framework of Chapter 3: one could study policy determination in both countries, possibly in a dynamic setting, such that the decision to assume a leadership role in environmental regulation—i.e., one country adapting a stringent policy in the hope of its diffusion—would be modeled explicitly. Such analysis may enable policymakers to identify more clearly the circumstances under which political leadership may be rewarded and beneficial both on a national as well as a global scale.

In a framework with incomplete enforcement, another step toward aligning the analysis with real-world policy determination would be to endogenize the likelihood
of firms being exposed in case of their noncompliance with regulation. Before the official draft outlining the policy enters parliamentary procedures, lobbies may influence the allocation of resources for enforcement in the proposed regulation. Alternatively, after the policy’s approval, they may seek to interfere with the efforts of the authorities charged with the policy’s enforcement. Either of these cases would require careful consideration on the part of the opposing interest groups as to how they may best expend their limited resources to impact the regulatory outcome. Both situations could, however, be analyzed in a two-stage contest model in which monitoring effort—equivalent to the likelihood of detecting noncompliance—is either determined by a political contest prior to the policy proposal or after its endorsement. Such a model could unveil new motives and strategic considerations for the interest groups’ lobbying efforts and track their effect on the political outcome.

New and additional insights could also be derived from simply changing existing exogenous parameters. This step could enrich the analysis and assist in explaining actual policies and/or arguments in the public debate, both of which may be driven by interest groups’ power. While an open economy is considered in Chapter 3, the focus of the three papers is mostly national as we contemplate national regulation, national lobbying, and local pollution, salient examples of which are particulate matter and NO\textsubscript{X}. If pollution was instead transboundary—such as greenhouse gases—of course, the incentives of environmental interest groups would change significantly. This setting is easily accommodated in the existing framework by changing the damage function accordingly. In that context, it might also be interesting to consider environmental interest groups that lobby internationally and to analyze their incentives—given their limited resources—to seek to change the regulatory outcome in different countries. While the collective action problem is more easily overcome for local than for global pollution, environmental nongovernmental organizations (NGOs) play an important role at the international level and the suggested extension would yield a deeper un-
By adding additional parameters, one could, for instance, consider border tax adjustments (BTAs), which—it is often argued—may be an effective tool to prevent environmental dumping and to win the support of industrial interest groups for environmental regulation. Political factors, however, have been largely absent from the analysis of BTAs and the impact of such a policy on the political incentives of the lobby groups may not be straightforward as it would implicate various changes to compliance cost as well as output and ensuing environmental damage. It seems plausible that an industrial lobby group would be less opposed to regulation if BTAs were capable of protecting the industry’s competitiveness, yet the reaction of a green interest group may be less clear and would hinge on a great number of factors: does the policy regulate product emissions or production emissions? What is the effect on local demand and supply? Similarly, is production mostly for the domestic market or for the global market, in which case BTAs could offset the environmental benefit of regulation? Is the regulated pollutant’s adverse effect purely local or transboundary? While some of the effects determining the answers to these questions may seem intuitive, only a rigorous analysis can accurately ascertain their impact on political choices. This would involve adapting our framework by, for example, reflecting BTAs in the demand and supply functions and by modifying the environmental damage function according to the type and extent of pollution. Given appropriate changes to the model, similar to our analysis of benchmarking, we would then be able to scrutinize the prevalent claims of policymakers regarding the advantages of BTAs.

Apart from endogenizing and modifying the exogenous parameters, extensions of the studies at hand could also be of an empirical nature. While it should be emphasized that the objective of this thesis was to derive new theoretical insights into the political determination of regulation rather than to test hypotheses about them empirically—i.e., hypotheses regarding the strategic behavior of lobby groups are the
output rather than the input of our work—two issues in particular could lend themselves to empirical verification: first, the model of benchmarking regulation we devise highlights the greater effectiveness and efficiency of environmental standards stipulated via relative performance mechanisms. As such tools have, to some degree, already been employed in actual policies, testing their efficacy would improve our understanding of relative performance mechanisms. The real-world policy possibly closest to our model is Sweden’s regulation of NO\textsubscript{X} emissions from large combustion furnaces. The empirical study by Sterner and Isaksson (2006) demonstrates the environmental effectiveness of this policy and, therefore, supports our results regarding the potential benefits of relative performance mechanisms. Further study of this and similar policies would, however, be useful. Nevertheless, in attempting to investigate relative performance mechanisms empirically, the availability of data, in particular of firm-level data, could be an obstacle that is not easily overcome. This also holds for the second potential area of empirical verification, namely, the influence of special interest groups. Rather few studies have sought to quantitatively assess the strategic interaction of interest groups in environmental policy. The few exceptions include Joskow and Schmalensee (1998); Riddel (2003); Fredriksson et al. (2005) and Anger et al. (2015) and some of these studies are limited to the analysis of one lobby group’s influence on regulation or the decisions of individual politicians. Due to the fact that the influence or contributions of individual lobby groups is hard to track, previous empirical studies have resorted to proxies such as the number of lobbies in a certain field of interest, the number of the lobbies’ employees, or simply the sales figures of the affected industry. Much could be gained in the understanding of political competition if future research was able to identify better proxies and collect more detailed data, which would allow for the more thorough empirical verification of lobbies’ impact on policy determination.

In addition, the policy contest framework we adapt is suitable for looking beyond
the regulation of emissions from production, which we focused on here, and for analyzing the role of lobby groups in determining alternative environmental policies, in particular, product regulation. For instance, in a two-country setting, it may be worthwhile to study policies restricting the emissions of the final product and the ensuing lobbying incentives of firms that sell this product in both markets. A typical example would be legal limits on (various) automobile emissions. If the product emits several pollutants—in line with the example of vehicles, say CO\textsubscript{2} and SO\textsubscript{X}—and regulation is fully enforceable, the industry may focus on trying to prevent the regulation of one of the pollutants. If successful, it could then apply the same changes to its product in both countries in order to abate the emissions of the other, regulated pollutant. On the other hand, if enforcement of regulation is incomplete, the incentives may change: in that case, the firm may choose not to comply with regulation and noncompliance is typically detected more easily if regulators in both countries check for compliance with the same kind of restriction. If, however, each country regulated a different pollutant, noncompliance with one or even both of the policies would be harder to detect and, therefore, facing divergent regulatory measures could be in the interest of the (noncompliant) firm. This insight could assist in explaining why the regulation of car emissions has traditionally centered around CO\textsubscript{2} emissions in the EU but is focused more on SO\textsubscript{X} emissions in the US and why major car producers (Volkswagen, in particular) were able to violate existing emission standards for a long time without being exposed. Building on the analysis of Chapter 4, a model of simultaneous political contests in the two countries would allow for the study of the altered lobbying incentives of the (representative) firm in such a setting and could establish additional, previously unidentified reasons for policymakers to cooperate internationally.

Finally, whereas the focus of our research has been on national policy and legislation, the influence of special interests plays a critical role in international environmental agreements and climate policy as well (see Dietz et al., 2012; Habla and Winkler,
Lobbying in this context, of course, happens on both the national as well as the international plane. Moreover, while the government faces the pressure of competing interest groups at home, at the international level it is involved in a contest itself as countries benefiting and those (seemingly) suffering from cooperation seek to enforce or prevent international agreements. A two-stage policy contest model may be able to shed more light on the lobbying incentives of the interest groups in such a setting, the strategic interaction of the countries, and the political equilibrium both on the national and international level. It could be rewarding to study the political interaction in light of, for example, the varying competitiveness of countries, differences in environmental vulnerability, the stringency of the agreement, or different policy instruments used to implement it. The results of such analyses may offer new insights into which regulatory tools are most promising in fighting global environmental problems multilaterally.

5.3 Lessons for policy

The objective of this thesis was to analyze the political process preceding the approval and ensuing implementation of environmental policy. At the same time, it is also meant to give guidance to policymakers and regulators. The first important policy recommendation to be drawn from our results is the potential for a greater role of relative performance mechanisms: when command-and-control policies are used, many of the typical shortcomings of this type of regulation can be overcome by introducing benchmarking or similar approaches. In some instances, policymakers have induced competition in environmental performance among the regulated entities already as, for example, the European Union promotes the use of best available techniques (BAT) in many sectors under its Industrial Emissions Directive. More recently, Germany

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2EU Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control); see European Commission (2010).
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has started to gradually move away from government-fixed subsidies for renewable energy and introduced competition among the providers of renewable power. The latest proposal to amend the Renewable Energy Sources Act (RES; Gesetz für den Ausbau erneuerbarer Energien (EEG)) is geared to expand the use of these competitive elements significantly.\textsuperscript{3} Based on our results of Chapter 2, such developments seem promising and more widespread use of relative performance mechanisms in environmental regulation ought to be encouraged.

Note also that the potential scope of applications of benchmarking regulation is considerable. One possible application could streamline the concessions granted to energy-intensive industries (EII) in a number of countries. The German RES, for example, provides EII with generous exemptions from a premium paid on electricity use, the so-called RES surcharge, which is used to finance the expansion of renewable power production. Although EII have to take certified measures to demonstrate their responsible and sustainable use of energy in order to benefit from this privilege, the introduction of a relative performance mechanism could provide further incentives for these firms to reduce their electricity consumption. Such policies could, for instance, involve abandoning the exemption and, instead, refunding the surcharge to the producers relative to their output. The self-selection into the exemption scheme and the relatively low number of affected firms should facilitate the definition of relevant industry groups that are appropriate for comparison via benchmarking. Note that EII enjoy very similar privileges, for example, in the UK, where energy-intensive producers can enter into a climate change agreement with the Environment Agency, as well as in France, Denmark, the Netherlands, and many other countries (see Fraunhofer-ISI and Ecofys, 2015). In these countries, benchmarking regulation may, hence, provide an equally useful method to improve the environmental performance of exempted firms.

The second important implication for policy is that regulators should be aware of the role and considerable influence of lobby groups. We identified some key drivers of lobbying, such as the vulnerability to pollution or the degree of competition in the affected industry, which could assist policymakers in adapting their own behavior, decision-making processes, and regulation to the relevant situation. It has been highlighted here and elsewhere that pressure from interest groups can be an important factor in internalizing the externalities of industrial production, however, it is often unclear whether the lobbies’ influence is predominantly in favor of regulation or opposes it and whether it enhances or reduces welfare. Whereas we only considered industrial and environmental special interests and for the most part assumed their equal representation, generally, this need not be the case and regulators and policymakers should be aware of the potentially incomplete representation of various and opposing interests. The level of effort that is exerted to support these interests hinges on a great number of factors and only a few of those—e.g., the characteristics of the regulated firms, the market, and the pollutant—were featured and could be analyzed in this thesis. The reaction of interest groups to proposed regulatory changes, however, can be more complex and anticipating their behavior should be a crucial element in adjusting the design of regulatory instruments, their proposed stringency, and possibly the political process itself. To reduce the danger of lobby groups repeatedly diluting regulation, far-sighted policy ought to include precommitment mechanisms and possibly also self-adjusting targets such as those stipulated via benchmarking.

These insights are, of course, not unique to environmental regulation. In principle, as long as beneficiaries of a (proposed) policy as well as those afflicted by it are able to organize into interest groups, the contest framework can capture the push for political influence related to any regulatory proposal that, if endorsed, would increase the cost of one group in order to promote the objective of another. As such, our model may be similarly informative for political economy analyses of diverse policies such as health
or safety standards, price ceilings for pharmaceuticals, increases in social benefits, animal welfare, banking regulation, as well as trade agreements. The latter, in particular, have recently been the subject of an intense public debate: the discourse relating to the ‘Trans-Pacific Partnership’ (TPP), the ‘Transatlantic Trade and Investment Partnership’ (TTIP), and the ‘Comprehensive Economic and Trade Agreement’ (CETA) has underlined the importance of the influence of special interest groups in determining the chances of legislative approval. At the same time it has also highlighted that such far-reaching political proposals may affect the lobbies’ political stakes in various and diverse ways—many of which were not accounted for here—and that, as a consequence, lobbies could amplify their efforts to sway the legislator and make it even more important for policymakers to react accordingly.

Thirdly, when drafting regulation to limit pollution, policymakers should account for the direct and indirect consequences of allocating (potentially insufficient) resources to monitor and enforce the legal restrictions following their approval. The importance of regulatory enforcement has recently been accentuated as a number of cases of noncompliance have caught the public’s eye both within the realm of environmental policy—the ‘Volkswagen scandal’ or, more generally, car emission standards, falsified energy labels of home appliances, etc.—as well as outside of it: the ‘Panama papers’ and ‘Luxembourg leaks’ to name but two. The resources devoted to enforcement, however, do not only determine the ultimate efficacy of the policy in question but also affect the likelihood of its approval. Taking note of the influence of lobby groups, our results suggest that incomplete enforcement may entail advantages and, therefore, could justify, for example, granting transitional periods during which existing firms are given some leeway in their compliance with newly implemented restrictions. Such initial phases, which are often part of real-world policies, allow for adjustments in the production process and the adoption of abatement measures.

\[4\text{Note that our model is suitable to analyze both the initial introduction as well as, if applicable, the diffusion of such policies to other countries.}\]
Moreover, they may reduce firms’ opposition to the implementation of regulation. As a result, it seems advisable for policymakers to recognize the effect of enforceability on both the policy’s effectiveness as well as on its political feasibility. Given that enforcement itself may be subject to the lobbying of (industrial) interest groups, however, it again seems expedient to strictly limit the potential use and extent of transitional periods via precommitment tools, for instance, by specifying the exact exemptions and their duration in the policy proposal.

It was already pointed out that many of the results derived above may not be limited to environmental regulation but could easily be adapted to other policy issues and yield similar results. Lobbying, after all, is certainly not restricted to the setting of environmental policy and neither is the importance of the enforceability of regulation. When adjusting their interpretation accordingly, our results may, therefore, offer insights for policymakers in many other fields. Nevertheless, environmental policy is the core field of application of our framework and analysis and today, strong and effective action to curb emissions is more necessary than ever. As was outlined above, more research is certainly needed on both the regulatory instruments as well as on the political process that shapes their design and application, however, it seems expedient for policymakers, regulators, and legislators alike to take account of the above recommendations when designing, proposing, and implementing environmental policies.

To conclude, while, of course, one has to bear in mind the limitations and assumptions of the analyses presented here and, therefore, cannot necessarily generalize from the findings at hand, Chapters 2-4 have provided a number of novel insights into the effectiveness of environmental policy instruments and the way they are stipulated. It is the objective of this thesis and hope of its author that these insights can contribute to guiding policymakers in the design of environmental regulation and that the political economy framework that was adapted to analyze the determination of environmental policy provides a useful tool for future research in this field and possibly beyond.
Bibliography


