DOCTORAL THESIS

# The Effectiveness of Environmental Regulations: Design, Implementation and Institutional Context

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Economics

LULEÅ UNIVERSITY OF TECHNOLOGY

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## Abstract

This doctoral thesis consists of an introductory preface and five independent papers, which all address the effectiveness of environmental regulations. The focus is on how regulatory design and implementation as well as institutional context could influence the outcomes of industrial pollution control. **Paper I** investigates the impact of performance standards on the Chemical Oxygen Demand (COD) discharges from Swedish pulp and paper mills over a four-decade long period. The analysis employs an instrumental variable estimation of the fixed effects panel data model and data for 22 individual mills. The results show that these COD standards have led to significant reductions in water pollution from the mills. However, the magnitudes of this effect differ across two regulatory regimes in Sweden, thus highlighting the role of the institutional context in which the environmental regulations have been embedded. **Paper II** focuses on how the adoption of compliance periods, i.e., granting industry extended deadlines to comply with new standards, has affected pollution reductions. This regulatory tool is discussed conceptually, and the empirical analysis relies on an extended version of the above data set, and a Panel Vector Autoregressive model. The results illustrate that the combination of COD discharge standards and compliance periods has been effective in reducing water pollution. High regulatory capacity will improve the effectiveness of this type of regulation. **Paper III** investigates the factors that help explain the duration of environmental licensing processes and devotes particular attention to the role of incomplete license applications. Theoretically, the industrial actors might have an incentive to submit environmental impact assessments (EIAs) that have a high risk of being deemed inadequate by the authorities. The analysis relies on an Accelerated Failure Time (AFT) model and data covering 1606 environmental licensing processes in Sweden, and that reached a final decision during the time-period 2018-2022. The results confirm that the high prevalence of incomplete applications has been strongly correlated with prolonged environmental licensing processes. The purpose of **Paper IV** is to investigate how environmental licensing procedures can be implemented, and the regulatory requirements designed, to regulate pollution without jeopardizing investments in novel zero-carbon or digital projects. This is achieved in the context of two licensing processes: Northvolt's battery factory in the city of Skellefteå and Facebook's data center in Luleå. The empirical analysis builds on an analytical framework, which provides the conceptual anchor for 20 semi-structured interviews with key persons involved in these two processes. The findings are consistent with the notion that well-functioning licensing processes will be characterized by three general attributes: flexibility, predictability and knowledge. These can be attained within the realms of existing legislation, in turn suggesting that successful green and digital transitions are likely not contingent on comprehensive legal reforms. Finally, **Paper V** provides a brief and conceptual discussion of the choice between economic instruments, e.g., taxes, and performance standards in environmental policy. This paper questions the claim that the former unequivocally represents a superior policy approach for mitigating pollution. Based on recent research, it is argued that the zero-carbon transition involves specific challenges that tend to strengthen the case for the use of standards. Moreover, standards-based regulations are not necessarily implemented as crudely as some economic models assume, and efforts could be undertaken to reduce compliance costs and encourage green technological change. Overall, the findings in this thesis are consistent with the notion that such efforts ought to acknowledge the entire set-up of the regulatory system, including knowledge generation and information-sharing as well as the nature of the relationship between regulators and industry.

*”Dear mama, how's it goin'?*

*Was the weather fair last week?*

*Dear mama, they were wonderful*

*All the sights you'll never see*

*And dear mama, if I could hold you, I'd grab you by the arms*

*Tell you what it means*

*You could take a worthless poor boy from the flats*

*And make him mean something”*

November Air – Zach Bryan

*Mom, thank you for everything. Someday we will meet again.*

*To my family,*

*who have nearly no clue of what I have been doing,*

*yet have supported me all the way.*

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*Kristoffer Sundström*
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## Papers

I. Sundström, K., and Söderholm, P. Environmental Regulation and Institutional Change: Industry Responses over Four Decades and Two Regulatory Regimes. Submitted.

II. Sundström, K., and Söderholm, P. Time Flexibility in Environmental Regulation: Discharge Limits and Compliance Periods in the Swedish Pulp and Paper Industry. Submitted.

III. Sundström, K. Incomplete and Delayed: How Uncertainty Drives Prolonged Environmental Licensing Processes.

IV. Sundström, K. Pettersson, M., and Söderholm, P. Environmental Licensing in the Green and Digital Transitions: Case Study Insights from Sweden.

V. Söderholm, P., and Sundström, K. (2025). The Institutional Blind-spot in the Green Transition: Market Incentives versus Command-and-Control. *Journal of Economic Issues* 59(2), 438-444.

## Contributions

The contributions of Kristoffer Sundström to the papers included in this thesis were as follows:

I. I contributed to the development of the idea of the paper and reviewed the relevant literature. I was responsible for collecting and merging new data with an existing dataset, developed the estimation strategy and conducted the estimations. I prepared an original (full) draft of the paper and collaborated with my co-author to produce the final draft.

II. I contributed to the development of the idea of the paper and reviewed the relevant literature. I was responsible for collecting and merging new data with an existing dataset, developed the estimation strategy and conducted the estimations. I prepared an original (full) draft of the paper and collaborated with my co-author to produce the final draft.

III. I am the sole author of the paper and was alone responsible for the development of all parts of the manuscript.

IV. I contributed to the main idea of the manuscript, the work on further elaborating an existing analytical framework as well as to the development of interview questions. I contributed to the data collection, e.g., performing half of all interviews and the transcriptions. I prepared an original (full) draft of the paper and collaborated with my two co-authors to produce the final draft.

V. I contributed to the main idea of the manuscript, the review of the existing literature and the discussion. I prepared an original (full) draft of the paper and collaborated with my co-author to produce the final draft.

# Contents

# Preface

## 1 Background and Purpose

As the global community looks to solve the problem of climate change by transitioning to zero-carbon industrial and energy production technologies, policies such as carbon taxes and public support to these types of technologies have been implemented. However, at the same time, it is frequently claimed that other existing policies and regulations stand in the way of an efficient climate transition, not least the environmental licensing processes and associated regulations that aim at safeguarding local environmental values impacted by industry and energy operations (Ruhl and Salzman, 2023).

These values include, for instance, water quality, biological diversity, and clean air and water. In other words, the environmental licensing processes are argued to pose potential hurdles to green projects attempting to provide green (climate) benefits, sometimes referred to as the green versus green dilemma (e.g., Söderholm and Pettersson, 2025). For instance, the construction of a battery production facility, i.e., an operation that is crucial for the electric vehicle industry and the climate transition, can nonetheless generate negative local environmental impacts.

For this reason, increased attention has been devoted to the effectiveness and the expedience of environmental licensing processes in industry and the energy sector, and this has also sparked a debate regarding the need for regulatory reforms. Practitioners and scholars alike have voiced concerns about current regulatory practices, which they argue to be too bureaucratic, uncertain and complex (e.g., Decker, 2003; Hayes, 2015; Howard, 2015). There are also concerns about lengthy processes, as well as the negative consequences of licensing delays (e.g., Pettersson et al., 2010; Bendor, 2009; Howard, 2015).

Furthermore, the environmental regulations that are included in the licenses granted to industry, e.g., technology and performance standards (see further Section 2), tend to have a relatively bad reputation in the existing literature. Economic instruments, e.g., pollution taxes and emissions allowance schemes, are claimed to promote emission reductions in a cost-effective manner and provide strong incentives for green technological change (Goulder and Parry, 2008). In contrast, the standards-based regulations, e.g., plant-specific performance or technology standards, are typically portrayed as inflexible, inefficient, costly, and, for these reasons, inferior to economic instruments (Baumol and Oates, 1988).

Still, in this thesis, we recognize that the effectiveness of standards-based regulations will likely depend on the institutional context in which these are implemented, and how they are designed (Gunningham, 2009; Kemp and Pontoglio, 2011). Specifically:

> *the aim of this thesis is to investigate how incentives, institutional arrangements and regulatory design influence the effectiveness of environmental regulations.*

The research is centered around three main themes: (a) the impacts of environmental regulations (e.g., performance standards) on industrial pollution outcomes, including how these impacts vary across various institutional (historical) contexts; (b) how existing environmental licensing procedures can be implemented, and the standards designed without jeopardizing investments in novel (e.g., zero-carbon) projects; as well as (c) the choice between economic instruments and standards in industrial pollution control, again with an emphasis on the role of institutional contexts (e.g., regulatory cultures, knowledge generation, information-sharing, trust).

These themes are investigated in the empirical context of the Swedish environmental regulation and licensing procedures. Sweden also has a long history of environmental regulations, not least in the country's pulp and paper industry (Söderholm, 2009), and performance standards have long served as a central tool for reducing industrial pollution. Moreover, the Swedish regulatory system experienced a noteworthy regulatory regime change with the adoption of the so-called Environmental Code (in 1999); this provides an opportunity to study how such an institutional change has influenced the effectiveness of environmental regulations. Finally, the green versus green dilemma is a topical issue in Sweden. Several projects that contribute to the green as well as the digital transition have undergone environmental licensing processes (e.g., battery factory, data centers), and some of these processes have fueled the debate on the need for reforms of the existing regulatory system.

The analyses in the thesis build on a mix of methods. These include econometric approaches, i.e., Instrumental Variable (IV) estimation of the fixed effects panel data model, the Panel Vector Autoregression (PVAR) model, and the Accelerated Failure Time (AFT) model. In addition, one of the papers builds on a case study approach, which combines semi-structured interviews and an in-depth analysis of license applications, rulings and regulatory requirements.

## 2 The Environmental Licensing Process and Thesis Contribution

The environmental licensing process is the formal procedure through which the responsible regulatory authorities evaluate and authorize projects or activities that could have significant impacts on the natural environment, ensuring they comply with prevailing environmental laws and standards before they can begin. This process typically involves a case-by-case assessment of the potential environmental impacts of a proposed project through an Environmental Impact Assessment (EIA). If a (new or renewed) license is issued, it includes regulatory requirements in the form of, for instance, technology and performance standards. Figure 1 provides a generic illustration of an environmental licensing process, and it serves as a starting point for discussing the different stages in more detail, the actors involved as well as for briefly introducing the focus of the research topics and papers included in this thesis.

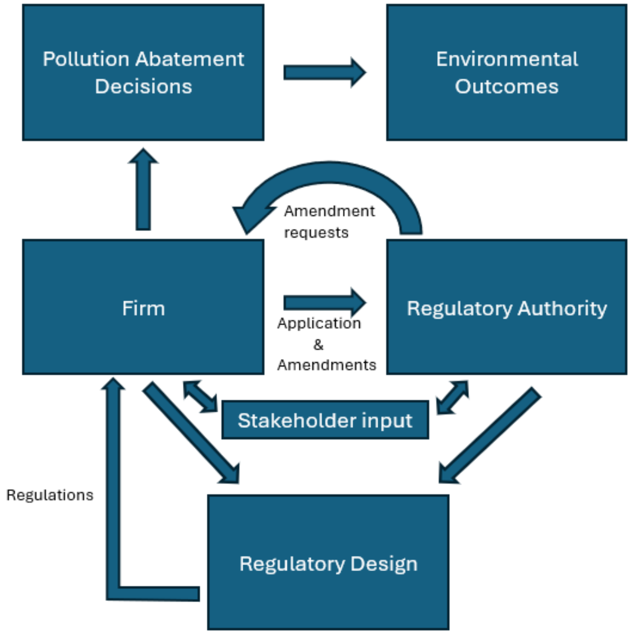


**Figure 1: The environmental licensing process: a generic description**

An important point of departure for the analysis of environmental licensing processes is that they will typically involve, not least in the case of large projects, close continuous interactions between industry and the regulatory authorities (Rothwell, 1992). In other words, this suggests that in this context, environmental regulation should generally not be viewed as a simple case of stimulus and response. It is a process, which contains opportunities for experimentation and learning on the part of both the industry and the authorities (Farber, 1994). The outcome of the licensing processes will in turn be influenced by how the relationship between these actors is shaped over time, not least the extent to which they share knowledge and deal with uncertainty about both environmental impacts and the potential of various pollution abatement solutions (e.g., Bergquist et al., 2013).

Figure 1 illustrates that when a company is looking to start operations (or increase production at an existing operation) that might have negative environmental impacts, it needs to apply for an environmental license from the responsible regulatory authority. The authorities review the application, identify any shortcomings and decides whether amendments (revisions) are needed (e.g., due to potentially significant impacts being overlooked in the EIA). If amendments are needed, the application is sent back to the firm, which will amend it and submit a new version. In this process, both the company and the regulatory authority may consult various stakeholders such as other government agencies (e.g., environmental protection agencies, regional councils).

This early stage of the environmental licensing process involves a lot of uncertainties due to information asymmetries between firms and the regulatory authority (Söderholm et al., 2022). First, the industry will often possess an informational advantage concerning the availability and the costs of the various pollution abatement measures. Second, however, when preparing its application, the company may be uncertain about the specific legal requirements that must be met to obtain an environmental license (e.g., what to include in the EIA). The uncertainty also concerns how the authority will choose to interpret legal rules, handle incomplete applications, and weigh in stakeholder input in the specific context of the company's own operation.

Paper [3] addresses this second challenge. Conceptually, we can think of the company choosing between two strategies in preparing its license application. It can 'over-compensate' and thus prepare an application that attempts to meet all potential requirements. Alternatively, it can submit an application that has a high risk of being deemed incomplete. The advantage of the latter strategy is that it could elicit a useful response from the authority; the feedback provided (requests for amendments) can reveal implicit rules, preferences, and interpretive tendencies, which the company in turn can use to reduce uncertainty. Paper [3] reports that the share of incomplete environmental license applications has been high in the Swedish regulatory context, and it employs data of more than 1600 environmental licensing processes to investigate how such behavior – and other factors – have influenced the total duration of these processes.

After the initial license application has been submitted and any subsequent amendments made, the regulatory authorities make a final license decision (thus ending the process). This license includes specific conditions, i.e., standards addressing various types of environmental impacts (e.g., air and water pollution). For large projects, deciding on the design and stringency of these standards involve negotiations and dialogues with the company, this to ensure that the license conditions are economically and technically feasible and provide effective pollution control.

Papers [1] and [2] investigate the *impacts* of standards, specifically performance standards, on water pollution in the empirical context of Swedish pulp and paper mills, i.e., the link between regulatory design and environmental outcomes. Paper [2] devotes particular attention to the use of so-called compliance period, i.e., a type of regulatory design granting industry an extended deadline to comply with new standards. Because the decisions on standards and compliance periods are preceded by an (occasionally) extended process of consultations with the regulated industry, both papers acknowledge the possibility that these regulations will not be exogenously determined and use econometric specifications with endogenous regressors.

Both papers also discuss – and illustrate empirically – the notion that the impacts of regulations often will depend on the institutional context in which these are implemented. Previous research has emphasized how a regulatory style characterized by trust and information-sharing between the industry and the regulatory authorities provides fertile ground for large pollution reductions and green technological change (Gunningham et al., 2003). In addition, the use of compliance periods will likely be more effective in the presence of high regulatory expertise (e.g., Strasser, 2017).

Paper [4] considers the entire environmental licensing procedure and takes stock in the question of how this can be implemented, and the regulations designed to achieve positive environmental outcomes without jeopardizing investments in novel projects, such as those contributing to the climate transition. Previous research, including the seminal work by Porter and van der Linde (1995), has emphasized the importance of 'well-designed' environmental regulations, but tends to have little to say about what this implies in practice.

The conceptual starting point for Paper [4] is an analytical framework, which based on existing literature (e.g., Söderholm et al., 2022), describes some important attributes of a well-designed licensing procedure, including important interactions and trade-offs. These attributes include, among other things, licensing conditions characterized by flexibility in the form of performance standards and the use of compliance periods, predictability in terms of timely and transparent decision-making, and actor dialogues that are based on high regulatory expertise and trust-based information-sharing. In the paper, this analytical framework is applied in the empirical context of the environmental licensing of two novel projects in northern Sweden.

The previous research work that forms the basis of the analysis in Paper [4] suggests that there are several ways in which environmental regulations, plant-specific standards, can be designed and implemented in an efficient manner. Still, such regulations are frequently criticized for their perceived inefficiency and rigidity, not least in the economics literature. Market-based policies such as emission taxes or tradeable allowance schemes are often regarded as superior policy instruments since they provide continuous incentives for pollution abatement whilst achieving environmental objectives at a lower cost (e.g., Goulder and Parry, 2008).

Paper [5] provides a discussion of the choice between market-based instruments and standards, and (again) emphasizes the importance of acknowledging the institutional context in which the various policy instruments are implemented (see also Swaney, 1992). It also contends that the current transition towards zero-carbon technologies sometimes involves specific challenges that strengthen the case for a standards-based approach to environmental regulation. This type of regulatory approach is not necessarily adopted as crudely is sometimes assumed, and as shown in Paper [4], efforts can be undertaken to reduce the cost of compliance and incentivize green technological change.

Taken together the five papers in this thesis study different stages of the environmental licensing process, from the application phase to the environmental outcomes of the regulations imposed on industry. This section has outlined how these separate research studies relate to each other, while their specific contributions to the literature are discussed in each paper.

## 3 Summary of Papers

This section includes the summaries of the five papers included in this thesis. These summaries briefly describe the purposes, data, methods and empirical results of each paper, while the next section discusses the results and their implications in more depth.

**Paper I:** *Environmental Regulation and Institutional Change: Industry Responses over Four Decades and Two Regulatory Regimes*

The purpose of this paper is to investigate the impacts of environmental regulations on reduced water pollution. This is achieved in the empirical context of discharge limits and Chemical Oxygen Demand (COD) discharges in the Swedish pulp and paper industry for four decades, also highlighting the role of a major regulatory regime shift in the country. The analysis relies on an instrumental variable estimation of the fixed effects panel data model with endogenous regressors, using data for 22 Swedish pulp and paper mills over the time-period 1981-2020. The results suggest that the implementation of gradually more stringent COD limit values has led to significant reductions in water pollution from the mills. However, the magnitudes of this impact differ substantially across the two regulatory regimes, and where the most profound regulation-induced COD discharge reductions took place during the early regulatory regime. This finding is consistent with the notion of rising marginal pollution abatement costs but also with previous research indicating that this regime was based on an effective regulatory style, in turn providing plenty of opportunities for deep emission reductions and green technological change. Future research should acknowledge the importance of the institutional contexts in which various pollution regulations are embedded.

**Paper II:** *Time Flexibility in Environmental Regulation: Discharge Limits and Compliance Periods in the Swedish Pulp and Paper Industry*

The purpose of this paper is to investigate the effectiveness of industrial pollution regulations with a focus on temporal flexibility through the adoption of compliance periods, i.e., granting industry extended deadlines to comply with new standards. This regulatory tool allows firms to test and evaluate various pollution abatement solutions, and the regulatory agencies to decrease the uncertainties associated with imposing more stringent discharge limits. The analysis relies on a Panel Vector Autoregression (PVAR) model with endogenous regressors, and data covering 22 Swedish pulp and paper mills over a four-decade long period (1981-2020). The results show that the combination of discharge limits and extended compliance periods has been effective in reducing Chemical Oxygen Demand (COD) discharges in this industry. Still, the analysis also sheds light on the role of a major regulatory regime shift in the country, and the results illustrate that the use of compliance periods did only contribute to COD discharge reductions during the early regime. This finding is consistent with case study research suggesting that this regulatory regime relied on substantial regulatory capacity; the responsible authorities were well-equipped to verify or challenge the information provided by industry on various abatement options during the compliance periods.

**Paper III:** *Incomplete and Delayed: How Uncertainty Drives Prolonged Environmental Licensing Processes*

The objective of this paper is to investigate the factors that could help explain the duration of environmental licensing processes, and with special emphasis on the role of incomplete license applications. It is typically difficult for the regulatory authorities to provide firms with sufficient information about all the requirements that must be met for their applications to be considered complete. In light of such initial uncertainty, firms may have an incentive to submit applications that risk being deemed incomplete. This reduces upfront costs and constitutes a way of probing for more information, which could later be incorporated in a revised application. The analysis of licensing process durations relies on the use of the Accelerated Failure Time (AFT) model, and data covering 1606 environmental licensing processes in Sweden that have reached a final decision within a five-year long period (2018-2022). The results illustrate that a large majority of submitted license applications were deemed incomplete and this is strongly correlated with longer processes. The analysis also displays significant variations across industries and process types, reflecting differences in the complexity and the standardization of licensing processes. Potential ways to address the presence of incomplete applications include increased pre-review support from the authorities, guidance on how the legal rules ought to be interpreted in specific cases, and competence-building efforts among applicants.

**Paper IV:** *Environmental Licensing in the Green and Digital Transitions: Case Study Insights from Sweden*

The purpose of this paper is to investigate how existing environmental licensing procedures can be implemented, and the licensing conditions designed to regulate industrial pollution without jeopardizing investments in novel zero-carbon or digital projects. This is analyzed in the context of the environmental licensing of two greenfield investments in northern Sweden: one battery factory and one data center. The conceptual point of departure is a generic analytical framework, which, based on the existing literature, describes some important attributes of a well-designed environmental licensing procedure, including some important interactions and trade-offs. The empirical analysis builds on written material and 20 semi-structured interviews. The findings suggest that these two licensing procedures, notwithstanding the fact that both dealt with novel ventures in operations for which there was little prior experience, comprised many key elements of well-designed environmental regulatory approaches. Based on the above, the paper tends to question the frequently repeated narrative that more radical regulatory reforms are required by, for instance, assigning a more prominent place for projects' downstream climate benefits in the licensing processes, e.g., through regulatory exemptions, preemption, and 'fast tracks'.

**Paper V:** *The Institutional Blind-Spot in the Green Transition: Market Incentives versus Command-and-Control*

This paper questions the neoclassical claim that compared to command-and-control instruments such as performance standards, economic policy instruments (e.g., taxes or emission allowance schemes) represent a superior policy approach to mitigate industrial pollution. Based on recent research, we argue that the ongoing transition towards zero-carbon production processes will often involve specific challenges, which tend to strengthen the case for using standards-based regulations, not least quantitative performance standards. Empirical research suggests that this regulatory approach is not necessarily adopted as crudely as some economic models suggest. Efforts can be undertaken to reduce the cost of compliance and incentivize green technological change. These should, it is argued, address the entire set-up of the regulatory systems, including knowledge generation and information-sharing, trust, and the forms of relationships between regulators and industry. All in all, it is essential to abstain from simplified normative arguments about instrument choices in environmental policy regardless of the institutional context.

# 4 Findings, Implications and Future Research

The discussion in this section is organized around the three themes introduced above, i.e., the effectiveness of standards-based pollution regulations, well-designed environmental licensing procedures, and instrument choice in environmental policy.

## 4.1 The Effectiveness of Environmental Regulations

Papers [1] and [2] investigate the effectiveness of environmental regulations in the empirical context of COD discharges from 22 Swedish pulp mills over a forty-year period (1981-2020). Paper [1] focuses on the impacts of performance standards (discharge limits) and finds that these played a central role in reducing industrial water pollution. These results align with earlier qualitative research, which has suggested that the use of discharge limits in the Nordic countries has encouraged significant improvements in the environmental performance of pulp mills (e.g., Saether, 2000; Similä, 2002; Söderholm et al., 2017).

However, the effectiveness of these performance standards appears to be considerably lower after the above-mentioned regulatory regime shift in 1999. This result is overall consistent with the notion that the impact of environmental regulations will be influenced by the institutional context in which these regulations are implemented. The earlier regulatory regime, pre-1999, was consensus-seeking, and involved expert-based negotiations regarding both the timing and the contents of the regulations (Bergquist et al., 2013). Moreover, the licensing processes were shaped by intensive knowledge generation and information-sharing between industry and the responsible regulatory authority (Reinstaller, 2008). The more recent regulatory regime has, it is often argued, overall lacked the features that made the earlier regulatory regime successful.

Paper [2] focuses on the introduction of temporal flexibility through the adoption of compliance periods and shows that the combination of discharge limits and such extended deadlines was effective in reducing water pollution from the pulp mills. Also in this case, there are differences across the two regulatory regimes. The use of compliance periods did only contribute to reduced water pollution during the earlier regulatory regime, a result that is consistent with the notion that this regime relied on substantial regulatory capacity. These findings support results reported in previous case study research on other Swedish industrial sectors (Söderholm et al., 2022).

It is important to emphasize that the above results do not show that the above differences across the two regulatory regimes *caused* the heterogenous impacts in terms of the effectiveness of the pollution regulations. The point is simply that the empirical results are consistent with these various institutional contexts. Moreover, there are alternative explanations for these results, the most obvious being that it is likely that the availability of low-cost abatement opportunities was higher during the earlier regime in comparison to the latter (see however Paper [1] for a more nuanced discussion of this alternative explanation).

Both papers illustrate the importance of dealing with the endogeneity issues in estimating the effectiveness of environmental regulations, this because the environmental licensing processes have (throughout the studied time-period) involved consultations and outright negotiations between the authorities and the pulp and paper companies. This causes the endogeneity problem through reverse causality, i.e., where the firms manage to influence the regulators' decisions. There is potentially even a problem with regulatory capture in which the compliance periods and discharge limits mainly are tailored to correspond to the needs of the firms. The latter could potentially shed light on the relatively ineffective pollution regulations during the most recent regulatory regime in Sweden.

An important implication of the above is that policy makers must not view pollution regulation as a simple, one-time event that induces a single, well-defined firm response based on current information. They should instead view such regulations as continuous processes in which both industry and regulators learn and engage in knowledge generation and sharing. This implies in turn that the role of the regulatory authorities in the licensing processes should also be evaluated based on their ability to establish trust, cooperation, and productive dialogues among the actors involved over the content and timing of the regulations (Latin, 1985). At the same time, policy makers should be cautious of regulatory capture as they attempt to balance the trade-offs of the industry's possibilities and the protection of the environment. As argued in Paper [2], regulatory knowledge is key in dealing with the risk of regulatory capture; only then will the regulator be equipped verify (or challenge) the information provided by industry.

## 4.2 Well-designed Environmental Licensing Processes

Papers [3] and [4] investigate in different ways how the environmental licensing procedures could be implemented to reduce uncertainty, and the standards designed without jeopardizing investments in projects that benefit society.

Paper [3] investigates the factors causing delays in Swedish environmental licensing processes, and the results reveal that incomplete applications are strongly associated with longer licensing process durations. Incomplete applications are associated with a doubling of the duration of the processes. Conceptually, the paper argues that both the applicant (the company in need of a permit) and the regulatory authority could be the source of incomplete applications.

The applicant might deliberately be searching for shortcuts and/or gamble on their application being approved and will not therefore put in much effort in the preparation of the application. Alternatively, given the lack of sufficient information regarding the requirements connected to their application, the applicant may choose to submit a license application that has a high risk of being deemed incomplete to probe for additional information about these requirements. The regulatory authorities may also deal with uncertainties, at least in the early stage of the licensing process, in this case about the environmental impacts of the operation under review. For this reason, the authorities may fail to provide applicants with the information needed to close their knowledge gaps, this thus also contributing to many incomplete license applications.

An important implication of the above is that resources should be directed toward improving license application quality through enhanced information, pre-review support, clarification of the rules of law, information about legal interpretations and capacity-building initiatives for the industrial actors. Guidance on how the legal rules are likely to be interpreted in specific cases (e.g., types of industrial operations) is likely particularly important.

Paper [4] considers the entire environmental licensing procedure, and examines how this can be implemented, and the resulting regulatory conditions designed to provide effective pollution control without providing a barrier to significant investments in novel zero-carbon and digital projects. Our findings, which are based on the study of Facebook's data center and Northvolt's battery factory, suggest that these two licensing processes, notwithstanding the fact that both involved novel ventures, comprised key elements of what can be referred to as well-designed environmental licensing processes. Specifically, the licensing conditions were characterized by flexibility in the form of performance standards as well as compliance periods, predictability in terms of timely and transparent decision-making, and actor dialogues that were overall based on high regulatory expertise and trust-based information-sharing. In other words, the balancing act of regulating (local) environmental impacts without endangering projects in novel industrial ventures, was well-managed.

An important implication of these findings is that the existing legal rules in Sweden and the ways in which these are implemented in the environmental licensing processes performed well also in the context of new green and digital projects for which there is little prior experience. This in turn questions the frequently expressed argument that more radical regulatory reforms are required to, for instance, assign a more prominent place for projects' climate benefits in the licensing processes (e.g., through regulatory exemption, and 'fast tracks').

Finally, also Paper [4] raises questions about the issue of regulatory capture. In both cases, local politicians and authorities appeared eager to attract these high-profile projects to their respective municipalities. There is a risk that the responsible regulatory authorities have had a too strong focus on the main interests of the company, and the granting of the environmental license may have been perceived as a hurdle to be overcome once and for all. Such concerns represent an important avenue for future research.

### 4.3 Instrument Choice in Environmental Policy

The research presented in papers [1]-[4] show that the impacts and the efficiency of standards-based environmental regulations tend to be influenced by the ways in which these regulations are designed as well as implemented. Paper [5] takes stock in this observation and highlights the risks of relying on too simplified normative arguments about the pros and cons of various types of instruments in environmental policy. Specifically, it challenges the often-cited claim that economic instruments (e.g., emission allowance schemes or taxes) are inherently superior to standards-based instruments (e.g., performance standards) in mitigating industrial pollution.

Previous research, including parts of this thesis, shows that performance standards are often not implemented as crudely as some economic models presuppose and that these types of standards, and that they can encourage green technological change and substantial reductions in industrial pollution. Moreover, other policy criteria – beyond cost-effectiveness – may tilt the choice in favor of standards. For instance, to ensure policy durability and outcomes that are difficult to reverse, standards may be preferred to incentivize the early adoption and development of clean technologies (Caparrós et al., 2015). This will be especially important when novel technologies are not readily available, and the regulatory authorities are concerned about the employment and/or competitiveness impacts of the policy.

## 5 Overall Conclusions

The main objective of this thesis was to investigate how incentives, institutional arrangements, and regulatory design influence the effectiveness of environmental regulation. This research topic is relevant, in part since environmental licensing processes, in Sweden and elsewhere, have faced a lot of criticism from both industry and academia as these processes are argued to constitute hurdles threatening, not least, the climate transition.

The research demonstrates that standards-based regulations, often dismissed as too rigid and inefficient, can be used effectively when they are imbedded in systems that encourage adaptive implementation, and collaboration between the regulatory authorities and industry. Specifically, the Swedish experience shows that performance standards and the use of compliance periods have contributed to significant decreases in the pulp and paper industry's water pollution levels.

These findings are in turn consistent with the notion that institutional arrangements, regulatory capacity, and information-sharing between the actors are critical to the success of performance standards in reaching the intended outcomes. More broadly, the research demonstrates that the choice of policy instrument, e.g., taxes versus standards, is not the sole determinant of whether intended environmental outcomes will be reached effectively or not. Institutional context and regulatory design matters just as much.

The thesis also shows that inefficiencies in licensing processes often derive from shortcomings in the information flows and procedural structure of these processes. The companies applying for environmental licenses frequently struggle to meet the licensing application requirements, while the regulatory authorities can fail to properly communicate their expectations regarding the applications. This implies that delays in the environmental licensing processes are not solely dependent on administrative or structural issues, but also a result of information asymmetry and lack of coordination. Shortening the licensing process durations can therefore be linked to the improvement of information flows, regulatory capacity and expertise, and the encouragement of a procedural culture that encompasses mutual understanding and early engagement.

Previous research on the Swedish environmental licensing process has addressed the regulatory reform associated with the advent of the Environmental Code in 1999. This shift, it is argued, removed key features of the earlier regime, such as expert-based negotiations and procedural flexibility, thereby reducing efficiency. Nevertheless, the case studies presented in the thesis suggest that also the current regulatory system has the capacity to facilitate investments in novel projects in the green and digital transition while at the same time regulating the environmental impacts in an effective manner.

Since this thesis revolves around the Swedish context it is important to note that this somewhat limits the generalizability of the results to the regulatory systems in other countries. This does, however, open an avenue for future research on the effectiveness of various types of standards and important characteristics of other institutional contexts and regulatory systems.

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