Can mandatory disclosure help to reduce industrial pollution?

Assessing stakeholder use of the European Pollutant Release and Transfer Register in Germany

Lucas Wotzka

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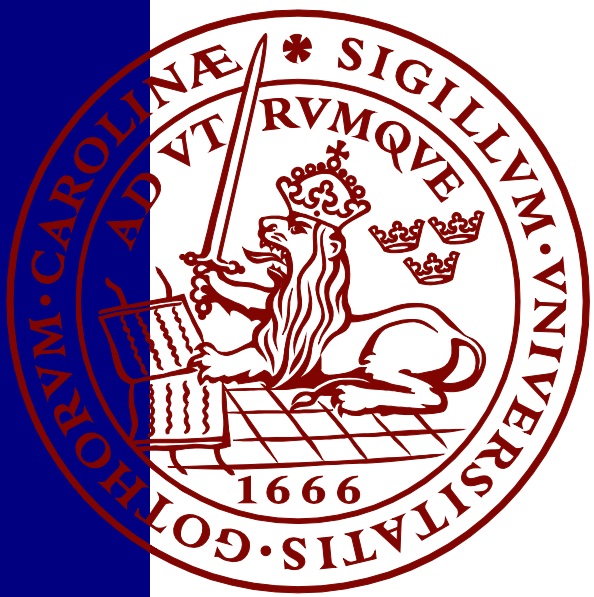

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Abstract

Industrial pollution abatement is key to accomplishing sustainability goals. Mandatory disclosure of pollution data, e.g. through the European Pollutant Release and Transfer Register (E-PRTR), promises reducing pollution through public pressure from stakeholders, such as NGOs, the media, and investors. This study surveys stakeholder use of the E-PRTR in Germany, using an analysis of press coverage, expert interviews, desk research and data analysis. Results indicate that use and coverage of the E-PRTR, due to limits in design and scope, have been limited to few experts and press articles, covering specific issues, such as coal power. Potential stock-price effects are limited, too. Relying on voluntary action by companies is a less promising civil society approach to industrial pollution abatement than influencing standard-setting. The E-PRTR plays a complementary tool in this. It can become more effective if suggested improvements are implemented.

Keywords: Environmental regulation, industrial pollution, mandatory disclosure, E-PRTR, press, NGO

Word count: 11,798 (including footnotes)

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Acronyms

CSR Corporate Social Responsibility.

E-PRTR European Pollutant Release and Transfer Register.

EEA European Environment Agency.

EPER European Pollutant Emission Register.

EU European Union.

EU-ETS European Emissions Trading Scheme.

IED European Industrial Emissions Directive.

MW Megawatts.

NGOs Non-governmental organisations.

OECD Organisation for Economic Co-operation and Development.

PFCs Perfluorinated compounds.

PM10 Particulate matter <10 µm.

PRTR Pollutant Release and Transfer Register.

TRI U.S. Toxics Release Inventory.

U.N. United Nations.

U.S. United States of America.

UNECE United Nations Economic Commission for Europe.

1 Introduction

> "I think the beauty of our job as members of parliament is that you learn something almost every day. I felt the same way, as did many colleagues, when we dealt with the Protocol on Pollutant Release and Transfer Registers under the Aarhus Convention. And that's when I learned that since 2007, both in Europe and in Germany, we have a register in which citizens can find out about the release of pollutants by industrial plants into the air, water, and soil, and about the transfer of waste and pollutants in wastewater. And every citizen can see this on the internet."

Florian Pronold delivered the opening speech in a German parliamentary debate of a change to the European Pollutant Release and Transfer Register (E-PRTR) on November 5th, 2020 (Bundestag, 2020). He had been a parliamentary state secretary in the German Ministry of the Environment for two and a half years[1], second in the hierarchy to the minister. His remarks raise questions about the utility of the pollutant register, in existence for more than ten years then, if not even he had ever heard of it.

Reducing industrial pollution is an important step towards attaining the U.N. Sustainable Development Goals (Organisation for Economic Co-operation and Development [OECD], 2021), including combating climate change, protecting human and environmental health (European Environment Agency [EEA], 2021b), and the EU Commission's "Zero Pollution Action Plan" (European Commission [EC], 2021). A significant part of pollutant releases in Europe stems from industrial-scale facilities, such as factories, power plants, farms, and waste management facilities.[2]

One policy approach addressing industrial pollution is mandatory disclosure in public databases. The first example of a Pollutant Release and Transfer Register (PRTR) was established in the U.S. following the Bhopal accident in India.[3] As part of the Emergency Planning and Community Right-to-Know Act (EPCRA), passed in 1986, the U.S. Toxics Release Inventory (TRI) has since obliged U.S. industrial facilities to disclose pollutant releases. It is seen as a success story, with significant reductions in toxic pollution since its inception, and even President Clinton publicly hailing the program (Hamilton, 2005).

Following the example of the TRI, pollutant registers are backed as tools furthering sustainable development by the United Nations Economic Commission for Europe (UNECE, 2016) and the OECD, which

[1] Pronold served in this position from 2013 to 2018, too, but then his main topics were construction and city planning (Bundestag, 2022).

[2] In the EU, energy supply (27 %), industry (21 %), agriculture (11 %) and waste management (3 %) together contributed more than 60 % of greenhouse gases (CO_2-equivalent) to the total footprint in 2019 (EEA, 2021c), 76 % of hazardous waste in the European Economic Area stemmed from industrial activities in 2016 (EEA, 2016), and the manufacturing and extractive industries alone accounted for large shares of cadmium (58 %), mercury (43 %), and lead (62 %) emissions in 2019 (EEA, 2021d).

[3] In December 1984, methyl isocyanate gas leaked from a pesticide factory owned by the U.S. company Union Carbide in Bhopal, India, causing thousands of immediate deaths. It is considered one of the most severe environmental disasters in history (Environmental Protection Agency [EPA], n.d.-a).

recommended PRTR adoption to all its members in 1996 (OECD, 1996). European countries established the European Pollutant Emission Register (EPER) in 2000, replaced by the European Pollutant Release and Transfer Register (E-PRTR) in 2006. PRTRs have also been established in Canada, Mexico, Australia, Japan, Israel, South Korea, and Chile (OECD, n.d.).

The rationale behind a PRTR is to provide the public with an accessible database of pollution information. An essential part, according to both E-PRTR legislation and theoretical literature, is to contribute to pollution reduction. PRTRs, especially the TRI, have been seen as a *quasi-regulation* that empowers stakeholders and the public, e.g. NGOs, the media, and local communities to regulate industrial pollution by creating accountability, participating in decision-making, and putting pressure on companies to improve their environmental performance (Konar & Cohen, 1997). As exemplified in the initial quote, the E-PRTR, at least in Germany, has not been as prominent as the TRI, raising the question whether the E-PRTR has fulfilled its promise and contributed to tackling industrial pollution.

In this study, I first introduce the E-PRTR and its relationship to other regulatory approaches. Then, I engage with the claim that pollutant registers can have a regulatory effect on industrial pollution on a theoretical level. The empirical part analyses the E-PRTR and its use in the context of the largest industrial economy in Europe, Germany. A mixed-methods approach comprising desk research, analysis of press publications, expert interviews, and data analysis is employed. Specifically, I investigate how and to what extent different stakeholders, such as the press, NGOs, and investors, have used the E-PRTR, the relevance, impact, and potential it has for industrial pollution mitigation, and how it could be improved, contributing to an assessment of mandatory disclosure through PRTRs as an environmental policy tool.

2 Background: The E-PRTR

2.1 Legislative background & reporting mechanism

Following the success of the TRI, and from ideas developed at the U.N.'s 1992 Rio Conference, the European Pollutant Emission Register (EPER) was established in 2000, and quickly replaced by the European Pollutant Release and Transfer Register (E-PRTR) as a mandatory, transparent source on pollution by industrial facilities, including public wastewater facilities and agriculture, in the EU and six adjacent countries.[1] Reporting to the E-PRTR is defined in European (European Parliament & European Council, 2006) and implemented in national law (Bundesamt für Justiz, n.d.). The number of included pollutants is much less comprehensive than in the TRI, which focuses on toxics[2], but the E-PRTR, unlike the TRI, includes greenhouse gases. Reporting thresholds in the E-PRTR are set individually for each pollutant, in contrast to comparatively low, universal thresholds in the TRI (Table 1). Compared to the EPER, the E-PRTR extended the number of included pollutants from 50 to 91, added waste as a category, extended the coverage of industrial activities, and mandated annual reporting (Umweltbundesamt [UBA], 2012). 2007 was the first reporting year of the E-PRTR, for which data was published in 2009.

A facility is obliged to report to the E-PRTR if it belongs to one of 65 industrial activities and exceeds a threshold amount of releases of a particular pollutant in a year. Reporting is also limited to facilities exceeding a capacity threshold, depending on its type of industry. Data is gathered and reported by operators themselves, which are obliged to use the best determination technique, e.g. calculation, direct measurement or estimation. Pollutant releases fall into the categories of emissions to air, water, and the ground; releases to wastewater; and hazardous and non-hazardous waste. Data is centrally published online by the German and European environment agency and includes geographical information, the name of the facility, industry type, and the amount released and threshold for each substance (EEA, n.d.; UBA, 2021a).

In the next section, the E-PRTR is placed in the European regulatory landscape on industrial pollution.

[1] Liechtenstein, Norway, Iceland, Switzerland, Serbia, and the United Kingdom.

[2] The TRI's scope has been widened and adjusted multiple times, including additional pollutants, adjusted thresholds, and reporting requirements (EPA, n.d.-a).

Table 1: Comparison of TRI (Code of Federal Regulations, n.d.; EPA, n.d.-b), EPER (EEA, 2015), and E-PRTR (EC, 2022e). Note: The number of industrial activities cannot be directly compared due to different classification systems between Europe and the United States.

	TRI	**EPER**	**E-PRTR**
First reporting year	1987	2001	2007
First data publication	1989	2004	2009
Reporting cycle	annual	2001, 2004	annual
Countries	USA	2001: EU15 + Hungary, Norway; 2004: EU25 + Norway	EU27 + Norway, Switzerland, Liechtenstein, Serbia, U.K., Iceland
Types of pollution	Emissions to water, air and soil; wastewater; waste; accidental releases; diffuse emissions	Emissions to water and air; wastewater	Emissions to water, air and soil; wastewater; waste; accidental releases; diffuse emissions
Covered pollutants	775 toxic and carcinogenic chemicals	50, including heavy metals, pesticides, greenhouse gases, and dioxins	91, including heavy metals, pesticides, greenhouse gases, and dioxins
Covered industrial activities	67 activities, industries include: Manufacturing, mining, energy, waste treatment, natural gas processing	56 activities, industries include: Energy, minerals, metals, chemicals, waste management, pulp and paper, intensive livestock production	65 activities, industries include: Energy, minerals, chemicals, waste and wastewater management, paper and wood production and processing, intensive livestock production and aquaculture, animal and vegetable products from the food and beverage sector
Number of facilities reporting in first year (approx.)	19,000	10,000	30,000
Thresholds	Absolute, annual threshold with exceptions for chemicals of special concern: 10,000 pounds for chemical use, 25,000 pounds for production; facilities with >10 full-time employees	Individual, absolute threshold for each pollutant; capacity threshold per industrial activity	Individual, absolute threshold for each pollutant; capacity threshold per industrial activity
Information provided	Geographical information, facility name, parent company, type of industrial activity, pollutant amount, pollution prevention practices, determination method, remediation efforts	Geographical information, facility name, type of industrial activity, pollutant amount, type of release, threshold, determination method	Geographical information, facility name, type of industrial activity, pollutant amount, type of release, threshold, determination method

2.2 The E-PRTR within the European regulatory landscape

Environmental pollution is an externality of economic activity not reflected by prices and thus requires regulation (Bünger, 2012, p. 449). Here, I compare command-and-control regulation, market-based approaches, and mandatory information disclosure as policy options to address this problem (Table 2).

Table 2: Comparison of regulatory approaches to industrial pollution and examples in the EU.

	Standards-based	**Market-based**	**Mandatory disclosure**
Main problem addressed	Excessive pollution	Inefficient allocation	Information asymmetry
Rigidity	Rigid	Flexible	None
Regulatory actors	Government	Market, government	Civil society, NGOs, media, investors, companies (self-regulation)
Example (EU)	European Industrial Emissions Directive (IED)	European Emissions Trading Scheme (EU-ETS)	European Pollutant Release and Transfer Register (E-PRTR)
Pollutants	Exhaustive list of environmentally relevant pollutants for each industrial activity	Greenhouse gases (CO_2, N_2O, PFCs)	91 key pollutants, including heavy metals, pesticides, greenhouse gases and dioxins

Command-and-control, or **standards-based approaches** set rigid limits and obligations for facilities, leaving little flexibility, but enabling control over pollution levels. At the same time, they bind administrative resources in monitoring facilities and setting standards for all types of industrial activities (Karkkainen, 2000). The European Industrial Emissions Directive (IED), passed in 2010, for example, sets emission limits for many industrial sectors for all relevant pollutants (EC, n.d.-b). Representatives of EU member states, industrial associations, and environmental NGOs form working groups to arrive at detailed conclusions about the state of technology for each industry, so-called Best Available Technique Reference Documents. This process thus involves lobbying and political negotiation between stakeholders. Pollution standards, such as air pollutant concentrations in exhaust, are binding for new facilities, and for existing facilities after a four-year implementation period. Facilities must submit a compliance report to authorities every year, and be in possession of evidence, such as pollution data, which is generally not made public.

An alternative policy option are **market-based approaches**, which leave more flexibility for operators. The market is used to regulate pollution by setting a price for pollution through a tax or a trading mechanism. The European Emissions Trading Scheme (EU-ETS), for example, targets greenhouse gases (EC, n.d.-a) and is limited to power generation, energy-intensive industries, and intra-EU aviation. Facility operators must be in possession of tradeable emission certificates. By controlling the number of certificates in circulation, a total emission limit is set, but it is not specified where releases take place. Price and location of pollution are determined by the market, which attaches an economic value to pollution that can influence businesses' decision-making.

Mandatory disclosure is designed to empower stakeholders by providing information and indirectly reducing pollution. It can remove information asymmetry and thus change the balance of power between businesses and the public (Leong & Hazelton, 2019; Stephan, 2002). Mandatory disclosure does not require significant administrative resources, is often easier to establish politically than binding regulation (Kotchen, 2013), and can cover many different pollutants. In contrast to voluntary disclosure in Corporate Social Responsibility (CSR) reporting, which allows companies to present themselves as sustainable (Leong & Hazelton, 2019), this data is published centrally on a per-facility basis, it is comparable, standardised, regularly submitted, quality checked, and has a defined scope (Sullivan & Gouldson, 2007). The E-PRTR is the only source fulfilling these criteria in Europe. In comparison with the IED, it covers a similar list of industrial activities, but less pollutants, with absolute reporting thresholds for pollution amounts.[3]

In the following, the possible role of mandatory disclosure through pollutant registers as a regulatory tool is discussed.

[3]The EU is in the process of streamlining the two regulations, particularly the list of industrial activities, as part of a revision of the IED, which seeks to align it with the goals of the European Green Deal (EC, 2022c).

3 Pollutant registers as a regulatory tool

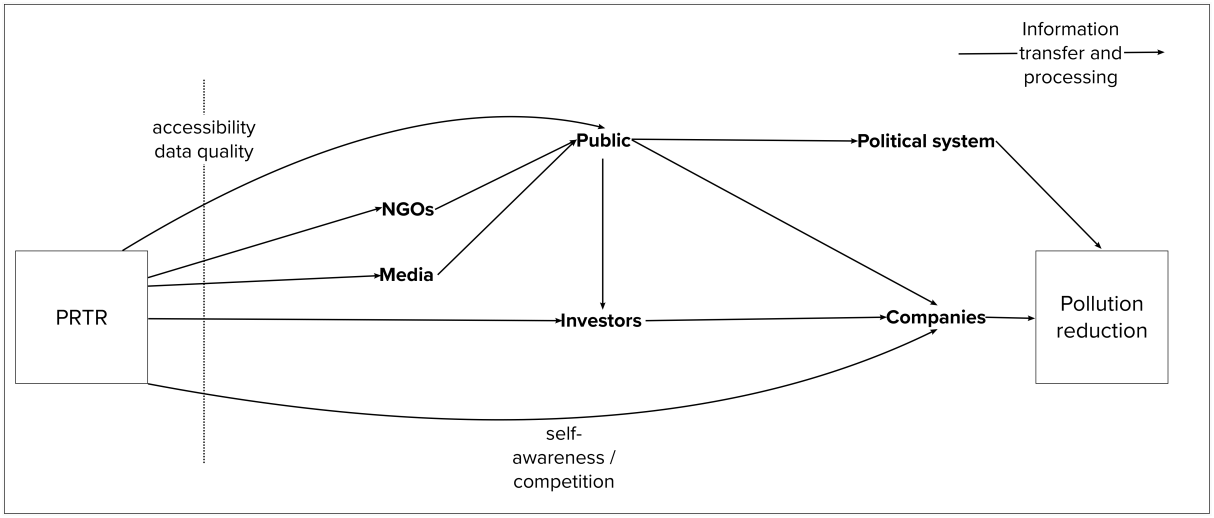

Figure 1: Stakeholder map depicting the theoretically derived mechanisms how PRTR data can lead to pollution reduction. Depiction my own.

Below, I outline the mechanisms how PRTRs may contribute to pollution reduction, focusing on stakeholders of industrial pollution (Figure 1). The claim that mandatory pollution disclosure is an instrument to lower pollution is made by both official documents and theoretical literature.

The establishment of the E-PRTR is tied to the Kyiv Protocol, becoming international law in 2009, that obliges signatories to implement PRTRs in accordance with UNECE's 1998 Aarhus Convention (EC, 2022a). The protocol mentions a PRTR's objective "to contribute to the prevention and reduction of pollution of the environment" (UNECE, 2022), expected to "to exert a significant downward pressure on levels of pollution, as no company will want to be identified as among the biggest polluters." (UNECE, n.d.). Likewise, the preamble of the E-PRTR legislation states that PRTRs "are a cost-effective tool for encouraging improvements in environmental performance" (European Parliament & European Council, 2006).

Thaler and Sunstein, in their famous book on behavioural economics[1], mention the Toxics Release Inventory as perhaps "the most unambiguous success story in all of environmental law" (Thaler & Sunstein, 2008, p. 190), an example of a *nudge*. The idea is that information disclosure, through public pressure, creates incentives for companies to reduce their pollution voluntarily, giving rise to a "kind of competition, in which companies enact more and better measures to avoid appearing to be significant contributors to toxic pollution" (Thaler & Sunstein, 2008, p. 191). In the following, the logic of this claim, its central aspects, actors, and assumptions are investigated.

[1] Richard Thaler won the Nobel Memorial Prize for Economic Sciences in 2017 for his contributions to behavioural economics.

3.1 Transparency

Pollutant registers have no direct effect on pollution, but provide public information. Transparency is a core value of good governance (Bünger, 2012, p. 444) and (environmental) democracy (Lynn & Kartez, 1994).[2] Hogner (2008) even sees PRTRs as a sign of a

> "new era not only of environmental regulation, but of a new era for communities — the public — to regulate the socio-environmental dimensions of economic affairs without undue reliance on regulatory bureaucracies, managed science, or market-directed notions of well-being."

This expresses the idea of "governance by disclosure" (Gupta & Mason, 2014), where the state takes the role of a "facilitator" (Scholz & Gray, 1997) and civil society, NGOs, the media, and academic research are empowered to become regulators through information provision.

The transformative potential of transparency can be divided into three dimensions: Normative, where transparency provides information as a value in itself; procedural, where actors are empowered to act based on information; and substantive, where disclosure improves environmental performance and reduces pollution (Gupta & Mason, 2014). PRTRs, as demonstrated, are expected to fulfil all three. The plausibility of this expectation is explored below through the aspects of data utility and accessibility, stakeholder pressure, and channels how this can result in better environmental outcomes.

3.2 Data quality and accessibility

Data accessibility and interpretation is a barrier that drives up the cost of obtaining information (Fung, 2013). If stakeholders do not know about, cannot access or use the data to derive conclusions compelling them to act, the mechanism of public pressure on companies breaks down. Even if data is freely available, it can be hard for ordinary citizens to understand it (Lynn & Kartez, 1994). Individuals with a special interest may be willing to invest the time and effort to access PRTR data, but broader population strata and the daily press are more likely be informed by intermediaries (O'Rourke, 2004), e.g. NGOs or the media. The latter, in turn, need sufficient resources and interest to make use of the data. Primary disclosure must thus run through one or several layers of information processing before becoming actionable (Mol, 2014).

3.3 Negative publicity

If the media, environmental groups, local communities and the public are able to pinpoint the worst polluters, this can give rise to a *blacklist* or *shock-and-shame* effect whereby polluters are exposed and face reputation damage. Fung and O'Rourke (2000) suggest that PRTRs enable "populist maxi-min"

[2] PRTRs are thus also seen as a possible role model for mandatory disclosure in other domains like digital platform governance (Ausloos et al., 2020), finance, or healthcare (Hogner, 2008).

shaming where maximum attention is paid to the comparatively worst (minimum) polluters. The public and stakeholders may be shocked to learn about the environmental consequences of an industrial activity, and this can influence their attitude towards companies. Mandatory disclosure may also impact industrial pollution indirectly by changing social attitudes towards the economy and its environmental impacts (Gray, 2007). It can thus serve an agenda-setting role, keeping the issue of pollution in the public sphere and influencing politics, e.g. in a way to tighten regulation (Stephan, 2002). *Shock and shame* can only be effective if polluters fear significant reputation or financial losses. For this to happen, data needs to be used by actors to sufficient effect: A "common criticism of transparency and data access initiatives (...) is that they are meaningless without an active civil society making use of the available data." (Ausloos et al., 2020, p. 51).

Environmental information can also influence investors in their decisions to buy and sell shares of publicly traded companies. Pollution disclosure can signal inefficient production processes, future cost, e.g. necessary investment, fines, or liabilities, and low competitiveness and future profitability (Eng et al., 2021; Nishitani & Kokubu, 2012). Individual and institutional investors, funds, banks and insurances increasingly value non-financial aspects of their investments and financial activities, including whether they are considered "green" or "dirty" (Termorshuizen, 2001; Tröger & Steuer, 2021). Companies may thus be wary of negative stock market repercussions from pollution disclosure and improve environmental performance either in reaction or preemptively. However, such a mechanism, too, is dependent on whether shareholders are aware of the disclosure, whether it presents new and conclusive information to them, and whether they decisively act upon it in relation to all other factors influencing their behaviour.

3.4 Reactions to mandatory disclosure

For businesses to change their decision-making, an external influence needs to be perceivable to the company and affect it. Information disclosure needs to be *embedded* into decision-making processes of businesses, as well as on the part of information users like consumers[3], the media or NGOs, to be effective (Fung et al., 2007; Weil et al., 2006). This can happen if information is used to draw attention to environmental issues, since organisations are sensitive to reputation losses and can be compelled to act on them (Sadler, 2016). It is rational for companies to make efforts to lower pollution if the perceived reputation or financial cost of disclosure is higher than that of lowering pollution (Laplante & Lanoie, 1994).

Mandatory disclosure may also allow companies to develop increased awareness of their own pollution and to compare themselves to competitors (Termorshuizen, 2001). Maxwell et al. (2000) assert that businesses can also be inclined to preemptively regulate themselves when fearing stricter government

[3] In the case of PRTRs, changing consumer behaviour is likely to play a lesser role, since most industrial facilities do not produce for the consumer market, and locally affected communities are not powerful enough to make a significant difference through their consumer choices.

regulation, particularly when the public can easily access environmental information.

There are several other factors influencing environmental decision-making of companies, for example profitability and economic crises and fluctuations, or changing regulation (Zettl et al., 2021). Companies' flexibility to reduce pollution can also be limited due to the availability of technology, the investment and time required to implement it, and existing regulation. Therefore, the significance of disclosure of environmental information in environmental decision-making can be questioned.

Moreover, companies have other options to react to negative publicity than to reduce pollution. They may evade negative attention by claiming confidentiality or seek other loopholes in reporting obligations, especially when values are self-reported: Companies may use favourable measurement techniques, split facilities up, outsource to other countries or to subsidiaries, or substitute pollutants by others not covered by the register. Reporting thresholds also provide incentives to stay just below them, but not to reduce pollution further. Businesses can also react to publicity by challenging the claims made or legitimising their performance through favourable research or compliance with regulation.

3.5 Summary: PRTRs and pollution reduction

Information can run through different channels and stakeholders to result in pollution reduction if some conditions are met: Data needs to be accessible and conclusive; stakeholders need to use it to create pressure. Businesses need to feel compelled to change their behaviour, in comparison with other factors influencing their decisions, and they need to have the flexibility to pursue pollution reductions. Alternatively, the political system needs to react to the publicity by adjusting regulation to reduce industrial pollution. Thus, there are many barriers for such mechanisms to be effective. In the following, I empirically investigate some of these conditions using the E-PRTR in Germany as a case study.

4 Empirical analysis

4.1 Previous empirical findings

Almost no previous empirical research exists on the E-PRTR or its predecessor, EPER.[1] The most detailed empirical assessment of the E-PRTR in Germany is done by a study commissioned by the German Environment Agency itself, analysing "the use and impact of the PRTR as an instrument to avoid and reduce environmental pollution" (Zettl et al., 2021). The authors point out negative trends in pollution can be observed in some areas since the establishment of the E-PRTR, but are difficult to attribute to specific causes, especially data disclosure itself. 12 companies whose facilities exhibit a negative trend of emissions are interviewed, finding no evidence of an impact of data publication. As the study concedes, "it is not known whether the PRTR actually contributes to a long-term promotion of an improvement of environmental performance". It also mentions data requests from the German E-PRTR, finding it has been used by the media, industry, and NGOs without providing more detailed results. Wider impacts of such data use were not identified.

Most of the empirical literature on mandatory disclosure and PRTRs is dated and focuses on the **U.S. Toxics Release Inventory**. Hamilton (2005) reviews the discussions around the impact of the TRI, including both case studies, qualitative and quantitative results. In line with other findings (Sand, 2005; Thorpe, 1994; Wolf, 1995), he deems emission reduction through right-to-know legislation a success, influencing authorities, media, communities, academia, and the industry alike, with emissions of toxic pollutants declining by 45 % in the period from 1988 to 1995 (Fung & O'Rourke, 2000). The success of the TRI can be seen against the backdrop of increasing environmental awareness at the time, with the register setting chemical pollution on the public agenda, especially for local communities, after large-scale industrial accidents. It was used by many citizens' initiatives to point out and rank worst polluters, generating a civil society echo to hold companies accountable and lobby for better regulation (Thorpe, 1994).

However, many questions remain unanswered, and the impact of the TRI in pollution reductions, according to Leong and Hazelton (2019), is "greatly overstated", given other factors, such as changed reporting techniques, regulations, market dynamics, and pollution outsourcing. Also, the empirical evidence about changed firm behaviour due to mandatory disclosure remains limited, except for some case-based evidence (Lynn & Kartez, 1994; Termorshuizen, 2001). A survey in the U.S. found that most ordinary

[1] A search inquiry in Web of Science on April 14, 2022, yielded only 37 hits for the term "E-PRTR", with all of them technical in nature or using E-PRTR data for answering research questions not related to the E-PRTR itself: Researchers have used it to study pollution in certain environmental domains, such as wastewater (Galvin, 2019), human exposure in different areas (Jephcote & Mah, 2019), pollution impacts on health (Fernández-Navarro et al., 2017; Lápez-Abente et al., 2012; Shaddick et al., 2018), and environmental efficiency in chemical production (Manello, 2017; Sörme et al., 2016). It has also been used to trace diffuse emissions in different sectors, such as shipping (Russo et al., 2018) and transport (Waygood et al., 2013). The E-PRTR and its geographical dimension have also been used to study environmental inequality, e.g. between polluted and less-polluted neighbourhoods (Rüttenauer, 2018), and the impact of pollution on housing prices in Germany (von Graevenitz et al., 2018).

citizens did not know about the TRI or facilities in their neighbourhood and attached little relevance to it (Atlas, 2007), raising doubts about the effectiveness of PRTRs as public awareness programs.

The literature on **media and NGO use of PRTR data** is also mostly limited to the TRI. Saha and Mohr (2013) find facilities receiving media attention did, subsequently, reduce emissions more than comparable firms not covered; Campa (2018) finds a similar result, but exclusively for facilities that produce consumer goods. Hamilton (1995) counts press articles mentioning facilities in the early phase of the TRI, finding 134 companies covered for their emissions, with media attention focusing on the largest polluters and those not previously known to be major polluters, and most companies not mentioned in the press. Konar and Cohen (1997) find 363 companies mentioned with respect to the TRI or toxic releases in 1989, with many press articles covering two major NGO reports analysing the emissions reported in the TRI. Lynn and Kartez (1994) study the use of TRI data by public interest groups, government agencies, and industrial associations, finding 95 documents from 1987 and 1990. They also find that both industry and NGO users believe the TRI has led to pollution abatement, and that media coverage of toxic pollution, as well as litigation, increased after the inception of the TRI, concluding that intermediaries were effective at linking disclosure to publicity. In the Japanese case, Ferraro and Uchida (2014) only find two companies mentioned in the press in relation to the Japanese PRTR, and 63 articles mentioning the PRTR in Japanese press overall in the year after its release. Press responses thus seem to vary between national contexts, and coverage is concentrated on the biggest polluters, after the first publication of PRTR data, and in the aftermath of NGO reporting, with substantial amounts of press attention in the case of the TRI.

Much of the literature assessing the impact of PRTRs is about **stock market reactions** to data publication. Several older studies have tried to estimate abnormal stock returns following the release of TRI (Arora, 2001; Bui, 2005; Hamilton, 1995; Joshi et al., 2005; Khanna et al., 1998; Konar & Cohen, 1997) and Japanese PRTR data (Hibiki & Managi, 2010). Hamilton (1995) finds that almost half of TRI facilities and at least 73 % of toxic releases reported stemmed from publicly traded companies, giving weight to a possible effect and serving as a comparison value. There are only two studies in the European context, both of which address the E-PRTR's predecessor, EPER (Cañón-de-Francia et al., 2008; Massier & Römer, 2012). In both the U.S. and the European context, studies find small, but statistically significant abnormal returns to company stock prices of around -0.3 % on the day of publication of PRTR data. As Bouzzine (2021), in his review of 38 stock-based event studies, notes, "there is consensus about stock price implications of pollution disclosures and that a firm has to expect to be penalized by investors for polluting the environment". However, as Capelle-Blancard et al. (2021) point out in a similar review, negative effects are small and last only shortly, doubtful to induce meaningful change in company behaviour. Some studies have tried to trace subsequent emission reductions to the size of the negative stock effect to establish a causal link, with limited quantitative evidence (Khanna et al., 1998; Konar & Cohen, 1997), while others do not find a significant stock market effect and point to command-and-control regulation

having produced negative pollution trends (Bui, 2005; Harrison & Antweiler, 2003).

The review of empirical literature shows that the argument that PRTRs can contribute to pollution abatement, especially in the European context and through use by media and NGOs, is scarcely substantiated. Most of the literature is about the TRI, indicating public attention created, but evidence is mixed concerning impacts on pollution levels, and if any, small stock market effects are found. Given the lack of previous research and the claims and assumptions made about it, an analysis of the E-PRTR is needed. The methods chosen to accomplish this are described in the next section.

4.2 Methods

To gather and analyse empirical material, a mixed-methods approach is employed: Semi-structured interviews, desk and press archive research, and data analysis paint a diverse picture of perspectives on the E-PRTR.

4.2.1 NGO use of the E-PRTR

To discover the ways NGOs used the E-PRTR, desk research using both general search engines and specific NGO website searches was used. A basis was provided by the list of large German environmental NGOs organised in the European Environmental Bureau (n.d.) and a list of officially approved German environmental associations (UBA, 2022). Search was limited to the German context, except for European initiatives involving German NGOs.

For further perspectives on the E-PRTR, five semi-structured interviews were carried out via video calls with experts on the E-PRTR (Table 3).[2] Additionally, the co-author of an investigative research report (Wehrmeyer, 2017) provided a written answer to some questions (S. Wehrmeyer, personal communication, April 11, 2022). The interviewees are experts with in-depth knowledge of the E-PRTR in the German and European context, authoring technical research reports and advising local initiatives, coordinating European NGO work on the E-PRTR and IED, administering the database for the government, and doing local environmental advocacy. The number of interviews is small due to the small number of experts on the E-PRTR. Interviewees referred to each other when asked for further contacts, indicating the sample represents the key individuals on the topic.

Due to the main research interest on use of the E-PRTR to create publicity and pressure, interviewees mainly represent pro-environment perspectives; industry behaviour was not the focus, advising caution in interpretation.[3] Using a semi-structured approach allowed respondents to enlarge upon their perspectives and allowed for interaction and flexibility. All interviews were recorded with consent of the interviewees, which were also informed about the intentions of the project.

[2] Interviews are cited as "IV" using their index in the table.

[3] A number of businesses with facilities reporting to the E-PRTR as well as relevant industrial associations were contacted, but did not respond to interview requests or questions.

Table 3: List of expert interviews.

	Name	Organisation	Type	Role	Duration	Language
1	Christian Tebert	Institut für Ökologie und Politik (Ökopol)	Private research institution	Technical expert, author of reports on industrial pollution for political actors and NGOs	60’	German
2	Sabine Grimm	Umweltbundesamt	German Environment Agency	Group leader facility-based reporting, responsible for German E-PRTR reporting and website	68’	German
3	Peter Gebhardt	Ingenieurbüro für Umweltschutztechnik (IfU)	Technical consulting firm	Environmental protection engineer, consultant for local citizen initiatives	50’	German
4	Claudia Baitinger	Bund für Umwelt und Naturschutz (BUND)	Environmental NGO	Local environmental activist, former leader of BUND’s working group on emission control	38’	German
5	Christian Schaible	European Environmental Bureau (EEB)	Association of environmental NGOs	Policy Manager for industrial production, European NGO coordinator in industrial pollution policy	67’	English

Interview guides were prepared with the help of interviewees’ public record of dealing with the E-PRTR. Questions were partly deduced from the theoretical framework to uncover the use and accessibility of the E-PRTR for various stakeholders and impacts of use. In addition, interviews were used to explore the ways in which NGOs and local initiatives work in the field of industrial pollution, to clarify the regulatory situation and reporting mechanism of the E-PRTR, and possible points for improvement of the register. Answers from earlier interviews were used in subsequent conversations to ask for agreement, differing opinions, or to consolidate understanding of issues.

Qualitative content analysis was performed in a stepwise approach inspired by Gioia et al. (2012): First-order topics and excerpts relevant to the research interest were identified for each interview.[4] Then, common themes, points of agreement and difference were compiled across interviews. These were aggregated under core dimensions for the presentation of results, which correspond in part to aspects from the theoretical framework and in part emerged from the interviews themselves, reflecting both deductive and explorative aspects of the interview strategy. Direct quotes are given room and translated where necessary.

4.2.2 Press coverage of the E-PRTR

Press coverage of the E-PRTR and its data was surveyed to gauge the extent to which media made the public aware of the E-PRTR and drew conclusions from it. The press was chosen as a medium due to the availability of complete historical records and being an important source for stakeholders, including politics, industry, and NGOs.

[4] Analysis was based on the recordings to capture meaning not reflected by transcripts. Machine-generated transcripts were used to facilitate the process.

Articles were compiled via the NEXIS, Genios and ProQuest press databases, which together cover almost all general-interest newspapers and magazines in Germany, including local publications. The following list of keywords was used for the search in the time frame from 2009, when E-PRTR data was first published, up to and including 2021:

> *E-PRTR, PRTR, European Pollutant Release and Transfer Register, Schadstofffreisetzungs- und Verbringungsregister [Pollutant Release and Transfer Register], Schadstoffregister [pollutant register], thru.de / prtr.bund.de [German E-PRTR websites]*

The 62 articles found can be assumed to approximate the totality of press publications which mention the E-PRTR. Text was fully accessible for 45 articles and partially for the rest; metadata was always available. Articles were systematically compiled in tabular form with the name of the paper, whether it mainly addresses a national or local audience, title, and date. Identical articles in closely related newspapers were only documented once.

I assessed whether articles address specific pollutants and companies, use negatively connoted language in headlines, and whether they explain the E-PRTR and its accessibility, e.g. by providing a link. Articles were categorised into coverage types emerging from analysis. To gauge the depth of reporting, articles of 200 words or less are classified as short notices, since such articles mostly represent agency news or appear in "shortly noted" segments.

4.2.3 Publicly traded companies in the E-PRTR

Much of the empirical work on PRTRs analyses stock market effects of PRTR publication. These works were reviewed in-depth, and an event-study approach was extensively tested using German stock market and E-PRTR data and preliminary calculations. However, inconclusive results, small sample sizes, shortcomings of the method and unclear interpretation limit its relevance for this study. Companies are heterogeneous regarding size, industry, pollutants emitted, and whether polluting facilities play a large role in their overall operations. Both theoretical arguments and empirical findings to make the mechanism of negative stock effects and subsequent pollution reduction plausible are thin, too, especially compared to the above-mentioned methods that enable an understanding of the mechanisms at play beyond quantitative data.

Thus, research into possible effects particular to publicly traded companies was limited to exploring evidence of E-PRTR use by environmental rating agencies, and the contribution of facilities belonging to publicly traded companies to the overall pollution reported in the German E-PRTR. As in previous studies, the first reporting year (2007) was used, which received the most public attention can thus be assumed to have the strongest potential effect. Of the four reporting branches of the E-PRTR (pollutant releases, wastewater discharge, hazardous and non-hazardous waste), only pollutant releases were considered, since they represent direct emissions into the environment, while the other types are handled by waste

management and sewage treatment.

A list of publicly traded companies was compiled from the German E-PRTR dataset (UBA, 2021a) based on the facility name, which matches a company name in most cases (in others, manual checks were performed), using the relevant legal types of stock companies. Companies are included if they were publicly traded at a German stock exchange at the time of first publication of the E-PRTR in June 2009. Companies that are subsidiaries of other companies are excluded, since it cannot be assumed that the plant in question represents a significant part of its operation, following an argument by Ferraro and Uchida (2014). To gauge the potential of any effect through stock market reactions to E-PRTR disclosure, I calculate the share of facilities belonging to publicly traded companies and their share of total reported pollutant releases for all pollutants.

4.3 Results & discussion

4.3.1 Accessibility, scope, and data quality

This section outlines criticism and limitations of the E-PRTR in terms of accessibility, scope, and data quality.

The first German website providing access to E-PRTR data had 450,000 page views on its first day of operation (Holdinghausen, 2009), June 3rd, 2009, but it presented data in a way "so that a normal citizen could hardly find or really make sense of them" (Hoffmann & Jacobs, 2013). The portal was overhauled in 2012 to provide better and easier access, but has largely maintained the same appearance since then, with poor usability remaining (IV1). Data is available for download in tabular and database formats, and the website provides search tools and filters as well as a map that allows searching for specific areas, companies, and pollutant types. The German Environment Agency receives on the order of 100 specific information requests from the E-PRTR a year on top of website use (IV2).[5] Online access could be facilitated and expanded, e.g. by providing and displaying time series, providing further data formats and more guidance on use and interpretation of the data (Zettl et al., 2021). This may allow for increased knowledge and use of the database, which, as the EU's own evaluations state, leaves room for improvement (EC, 2017; European Commission et al., 2016).

Publication of data happens in a yearly interval and so late that its value is diminished (IV1). E-PRTR data, in Germany, has to be published within 13 months after the end of the year for which reporting is done (Bundesamt für Justiz, n.d.). While this is already a long delay, especially for the media, which are keen on reporting about up-to-date issues, making it easier to challenge firms with current data (S. Wehrmeyer, personal communication, April 11, 2022), publication on the German website has usually taken place with an additional delay of several months.[6]

[5] Page view statistics, as well as specific data request statistics, were unavailable upon request.

[6] A list of publication dates for each reporting year, sourced from web archives and an information request to the German Environment Agency, can be found in the appendix (Table 7).

While for experts, the E-PRTR can provide information in a "few clicks" (IV3), for ordinary citizens, it is difficult to understand (S. Wehrmeyer, personal communication, April 11, 2022), as acknowledged by one interviewee: "[E]verything is online, yes, but if you need 5 minutes, then it requires getting used to. (…) It should be more user-friendly" (IV4). Seeking to overcome some of the issues of the official E-PRTR sites, the European Environmental Bureau set up an *Industrial Plant Data Viewer* (European Industrial Production Information Exchange, n.d.) by aggregating information from various sources and performing calculations on the basis of E-PRTR data to make them more conclusive (IV5). There exists a similar tool by the initiative Europe Beyond Coal (2022) for coal power plants. These are examples of non-governmental actors taking over the state duty to present and promote data due to shortcomings in accessibility and data quality (IV5).

Even if data can be accessed, the E-PRTR is not a list of firms with bad environmental records or illegal behaviour. It is a register of facilities above an absolute threshold of pollutant releases of a particular type. Reporting thresholds are a result of political negotiation. Without an environmental interpretation of thresholds, "then what do we need it for?", asks one interviewee (IV4). Despite this limitation, thresholds are used to identify heavy polluters by NGOs (IV4). For example, a Greenpeace report on water pollution tracks the trend of "heavy polluting" farms through the number of facilities above the reporting thresholds in the E-PRTR (Greenpeace, 2018a). The set-up of the database invites such interpretation of big facilities as heavy polluters, which is often unwarranted, unless time-consuming research is done, as one newspaper notes (Tupeit, 2013).

Coverage of the E-PRTR also has other issues: Thresholds are generally set high in order to protect small and medium enterprises from reporting burdens (European Parliamentary Research Service, 2022), meaning small facilities, sometimes being significant polluters, are not covered (IV3). In livestock agriculture, where ammonia (NH_3) is one of the main pollutants, ruminants (cattle and sheep) are excluded from the E-PRTR reporting obligation despite being a major source (IV1), and the reporting threshold for ammonia, roughly equivalent to a farm with 40,000 chickens, excludes many farms (Greenpeace, 2018b).

In addition, the E-PRTR does not include all industrial sectors, and some only partially: For example, combustion plants only have to report if their output exceeds 50 MW, which has been criticised for excluding too many facilities (Gibbs et al., 2020). The list of pollutants is a further limitation: The E-PRTR contains 91 pollutants, a small number compared to the TRI, and does not cover some types of pollution, for example emissions from liquid manure, black carbon and some types of pesticides (Zettl et al., 2021). Among others, this has the effect of the E-PRTR failing to reach its goal of covering 90 percent of industrial releases of many pollutants, sometimes by wide margins, both in Germany (Zettl et al., 2021) and Europe (Gibbs et al., 2020).

The E-PRTR also lacks crucial supplementary facility information, such as inputs (e.g. energy and water) and outputs (production volume), technology used, the legal standards and limits for each pollutant and

facility, or relative toxicity or greenhouse effect indicators for substances that would be crucial to assess and compare environmental performance (IV1, IV5).[7] Still, providing absolute pollution amounts can be valuable, particularly for civil society and local communities, for whom efficiency matters less than the total amount of pollution affecting their immediate environment (IV4). However, for air pollutants, for example, the register does not provide exhaust concentrations of pollutants, which are the relevant pollution measure (IV1). Beyond the local level, absolute amounts have little use in identifying plants with bad pollution records, particularly in the European comparison, although benchmarking would be a valuable application of the E-PRTR for all stakeholders, including the companies themselves (IV5). As the European Environmental Bureau notes, the E-PRTR "is currently not fit for purpose for supporting enforcement and benchmarking on industrial activities" (EEB, 2017a, p. 9).

Data quality shortcomings also include the fact that installations in the same location are grouped as one facility and thus, reported pollutant amounts cannot be attributed to a specific installation.[8] This is particularly hindering for precise technical analysis (IV1, IV2, IV3). In addition, facilities only have to disclose whether they measure, estimate, or calculate their pollutant releases. In many cases, this is not detailed enough, and some methods are too inaccurate to be reliable (IV1).[9]

The "mantra" of administrative burdens for both companies and authorities is the most important argument that hinders the strengthening of E-PRTR legislation by lowering or abolishing thresholds, and including more pollutants, industries, and supplementary data (IV5). The administrative burden of including a significantly larger number of facilities, according to the interviews, is manageable by authorities (IV2) as well as the industry, which often gathers the data regardless, e.g. for other purposes and reporting obligations (IV1). Reporting is typically burdensome in the first year and becomes routine for companies after a few (IV2).

As a result of the outlined shortcomings in design, even for experts, E-PRTR data is "quite useless" for meaningful analysis (IV1), e.g. to judge environmental efficiency, impact, or possible violations of other regulations: "For me it's a waste of time sometimes to even go [to the website]. There is nothing really interesting." (IV5). In some industries, E-PRTR data can be used to arrive at conclusions using complex methods. In others, it is impossible (IV1, IV3). In almost all cases, including the NGO reports described below, analysis requires more detailed data from other sources, for example through formal request from authorities, which typically costs a fee. This drives up cost of information (IV1, IV4) and binds authorities' resources (IV5): "[The companies] have this data, they have to monitor it. (…) The problem is, it is sitting

[7] Firms can report their output on a voluntary basis, but this is only done by about one percent of facilities, in the German register, according to 2019 E-PRTR data (UBA, 2021a). From 2023 on, facilities have to report output volume, but this data is not published, unless the facility gives their consent, which is voluntary (EC, 2022b).

[8] For example, if a business operates a waste incinerator for power generation next to a production plant, carbon dioxide emissions would be grouped for the two and therefore be inseparable for analysis.

[9] For example, in the case of air pollutants in exhaust, it is not disclosed whether measurements are taken continuously or following the *three-half-hour* method, which extrapolates yearly emissions from three half-hour measurements which can lead to very inaccurate results (IV1).

on some desks of some competent authority, who, if you ask them, they will ask the industry, and the industry will send it to them and they will maybe check it and then maybe give it to you" (IV5).

These aspects illuminate that there are limits to usability, access, and data quality of the E-PRTR. As the EU notes in its own evaluation of the E-PRTR, "[v]ery wide use of the website by the general public should not be expected as the E-PRTR will always be a niche product providing very specific information." (EC, 2017). Even for the experts, its information value is limited; one interviewee even referred to the register, in its present form, as a "toothless tiger" (IV1). However, it is a "good starting point" (IV5) to get a first impression of a particular industry and its most significant facilities and pollutants (IV1, IV3). Future revision of the E-PRTR can make it more valuable and effective as a tool if suggested improvements are implemented (IV1, IV3, IV5). The European Commission released a proposal for an update of E-PRTR legislation in April 2022 (EC, 2022d), which addresses some of the above-mentioned issues.[10]

4.3.2 The E-PRTR's role in NGO work on industrial pollution

Given the design of the E-PRTR as analysed above, its utility for environmental NGOs and local initiatives is limited. In the following, I describe how NGOs work in the field of industrial pollution, and to what extent E-PRTR data has been used in this context.

German industrial facilities, when expanded or newly built, require an official permit from a local authority in line with the IED and national regulation. In the process, citizens and NGOs can voice their objections. Once a permit is granted, it includes pollution limit values for relevant pollutants (IV1). Thus, local initiatives and NGOs focus their activity on influencing the permit process, given once granted, the operator has a legal basis legitimising its pollution (IV3, IV4, IV5). The E-PRTR, which covers only existing facilities and has no up-to-date information, usually plays no role in this permit process, and the involved parties often do not know or use it (IV1, IV3, IV4). Even in permit processes, the degree of activity by stakeholders is mostly low and concentrated in sectors stoking fear, such as waste incineration or coal power (IV3, IV4).

Challenging facilities that already have a permit, conversely, has high legal hurdles and requires much more detailed evidence than given in the E-PRTR (IV3). In addition, NGOs have limited resources, which they mostly allocate to permit processes instead of targeting approved facilities: "For each statement [in a permit process], I get 10 Euros. And I sometimes work on them for three weeks. (…) We cannot sink our teeth into some [existing] facility. We can only clench our fists in our pockets." (IV4). In such cases, making an impact requires long-term engagement by NGOs, involving on-the-ground measurements and arguing through local concern (IV1). With E-PRTR data difficult to acquire and interpret, awareness of a local environmental issue often has to be amplified by the press, which in turn can motivate larger NGOs to investigate the issue, in which case they may use the E-PRTR for a first impression (IV4).

[10] Proposed changes include the provision of contextual data (water, energy and raw material consumption, operating hours, production volume), a few further industrial activities to be added, and some changes to pollutant thresholds.

Hence, the E-PRTR does not play a significant role in civil society and NGO engagement against industrial pollution in Germany (IV4). For informed citizens, it can provide an overview or highlight big polluting plants in the neighbourhood (IV1), but knowledge about it is very limited even in activist circles:

> "The public does not know about this. That's what I realise when I talk to people. (…) Only some specialists do. Even [in my NGO], there are only very few people who work in this area. (…) The value is more an academic one. (…) It is not a restrictive tool. (…) It is not so known yet as it needs to be to build pressure." (IV4)

Directly challenging companies using E-PRTR data was not seen as a promising approach, in contrast to theoretical claims about public pressure: "The ordinary citizen always thinks one has to address the companies and their own responsibility, but they do not have it. (…) You have to address the authorities." (IV4). Interviewees acknowledged that companies fear for their reputation, and that their attention to environmental protection has increased since the late 1990s, when environmental matters became increasingly important to the public (IV1, IV2, IV3). At the same time, industrial businesses have collected experience in handling local initiatives, e.g. by listening to claims, but not necessarily acting on them: "They make good coffee and give you Christmas cookies, but then they are happy when you leave" (IV4). The prospect of industrial facilities significantly reducing pollution voluntarily beyond permits was called "utopian" by one interviewee (IV1), citing investment costs for more efficient technologies and competitive disadvantages. Sometimes, facility operators reduce pollution as a sign of good will to facilitate a permit process, or if technologies enable them to save cost or energy (IV3). This, however, is not the case for many technologies, for example air pollutant filters. If available, cleaner technologies eventually become legal standards and are therefore reflected by permits (IV3). Thus, even in the event of public attention, it is unlikely that shaming a facility will lead to pollution reduction through voluntary action.

Interviewees were thus unanimous in identifying the promising avenues to reduce industrial pollution: Decisively influencing permit processes and or building political momentum towards changes in environmental standards. In the process of setting European pollution standards as part of the IED, the E-PRTR is one of the tools experts use to identify key environmental issues and to check facility compliance (IV3), but use of the E-PRTR is limited to this preliminary phase and by the fact that reporting thresholds in the E-PRTR are too high for many purposes (IV5).

4.3.3 NGO publications using E-PRTR data

In contrast to some industrial nations, like Japan (Ferraro & Uchida, 2014), Germany has many environmental NGOs that influence public opinion (IV3). Most of them, according to my research, never explicitly mention the E-PRTR on their website or in their published documents, but some NGOs and other stakeholders have used E-PRTR data in their publications.

Most of the reports using E-PRTR data target coal power plants. One was a Greenpeace (2013) report titled "Tod aus dem Schlot [Death from the chimney]", which quantifies the number of deaths due to hazardous substances released by coal power plants. The E-PRTR was the source of pollution data for the individual facilities and thus an essential tool for the creation of the study. Linking industrial pollution to health effects, which requires deeper analysis, is particularly effective at creating public awareness and pressure by appealing to citizens' personal concern (IV5).

Another study, commissioned by the German Green party parliamentary group (Tebert, 2015), analysed mercury emissions from coal power plants as reported in the E-PRTR.[11] It pointed out emission savings potentials of 85 % using existing technologies, leaning on the E-PRTR with its facility-level data, which was used as a basis for the necessary, more elaborate calculations. The study and the attention it generated, in the media, NGOs, and in politics, decisively influenced the process of combating mercury emissions through better regulation. It drove technological experimentation and set off a process leading to significant reductions in mercury emissions (IV1). Addressing mercury pollution was also explicitly taken up by the Green party, now in the government, in its program for the German parliamentary election in 2021 (Bündnis 90/Die Grünen, 2021).

A similar report on nitrogen oxide pollution from coal power plants was commissioned by an NGO (Tebert, 2018), with findings indicating industry saves cost by not implementing existing, cleaner technology, since it is not needed to reach environmental standards. The E-PRTR was subsequently used to compile an input for a national legislative proposal on emission control in the context of coal power (Gebhardt, 2020).

These examples show that E-PRTR data, in combination with other sources and expertise, can make an impact through the political system if generating public attention. This was mostly the case with coal power, a prominent political issue in Germany.[12] Compiling data about coal power plants was also the main use in other publications using E-PRTR data, and the main reason one interviewee used the E-PRTR (IV3). For example, two German NGOs used the data for their "coal atlas" outlining the environmental impacts of coal mining and power plants (Heinrich-Böll-Stiftung & Bund für Umwelt und Naturschutz e.V., 2017). Pollution from German coal power plants is also the topic of several other publications advocating against coal power, with limited use of the E-PRTR to cite absolute emission numbers for reference (Bund für Umwelt und Naturschutz e.V. [BUND], 2017a, 2017b; Forum Ökologisch-Soziale Marktwirtschaft, 2021; Health and Environment Alliance, 2013; Heinrich-Böll-Stiftung, 2018; Myllyvirta & Gierens, 2021), and of major NGO publications on the European level (Climate Action Network et al., 2016; Europe Beyond Coal, 2021; European Environmental Bureau et al., 2017).

[11] The European Environmental Bureau (2017b) subsequently published an update on the findings of the report in 2017, which also uses the E-PRTR as one of its main data sources.

[12] In 2019, Germany set the goal of phasing out coal power, providing 28 % of electricity in the country (AG Energiebilanzen e.V. [AGEB], 2022), by 2038, but the new government, installed in 2021, agreed to "ideally" achieve this goal by 2030 (Bundesregierung, 2021).

Agriculture is one of the few industrial sectors other than coal power that were addressed by NGO publications: The German Federation for the Environment and Nature Conservation (BUND) published a "meat atlas" showing environmental effects of meat production in Germany (Bund für Umwelt und Naturschutz e.V. & Heinrich-Böll-Stiftung, 2016) and policy briefs about certain big facilities, such as Europe's largest pig farm (BUND, 2020), using E-PRTR data. Correctiv, an association for investigative reporting, in collaboration with Greenpeace, used the data to show which agricultural businesses received large amounts of European subsidies under the Common Agricultural Policy (CAP) while also being heavy polluters (Wehrmeyer, 2017). The existence of the E-PRTR with its high level of detail was key to this research. Like most of the studies on coal power, its criticism is mainly addressed at politics, not at facility owners. It also provides some evidence of fraudulent or evasive reporting by companies, e.g. by misreporting the number of animals, splitting up or outsourcing facilities to subsidiaries, and investing in farms just below thresholds. This uncovers loopholes in the self-reporting scheme of the E-PRTR, but it also shows that businesses take action to avoid publicity in the E-PRTR, pointing towards fear of negative repercussions of disclosure.

The German Environment Agency itself, which is responsible for the compilation and publication of the database in Germany, publishes reports and analysis on specific pollutants, industries, and pollution trends, using E-PRTR data (UBA, 2017, 2020a, 2020b, 2020c, 2021b), as does the European Environment Agency (EEA) (2011, 2018a, 2018b, 2021a). Government agencies are uniquely positioned, since they both publish the data and have the aim and obligation to contribute to environmental protection. With its publications, the German Environment Agency aims to create awareness of the E-PRTR and to motivate the public and stakeholders to use the E-PRTR (IV2). This highlights the value of E-PRTR data to the government itself, placing further analysis in the public domain that can be used by politics and NGOs, as happened with a press release by one German NGO following an EEA study (Deutscher Naturschutzring, 2019).

Overall, the E-PRTR was used by German NGOs, but only in a limited way. The few publications mostly highlighted coal power and agriculture, not other types of industrial activities or pollutants. Experts can use the data for specific purposes only. Their data use was summarised by one interviewee: "One cannot causally say, we have achieved something with the E-PRTR. One can say: We have used the PRTR as one of many sources of information, as one tool, for our work" (IV3). It would be a "huge loss" (IV3) not to have it, given it is the only source providing public access to pollution data for individual facilities, a rare quality for data publication in Europe given companies' desire for secrecy (IV5, S. Wehrmeyer, personal communication, April 11, 2022).

4.3.4 Press coverage of the E-PRTR

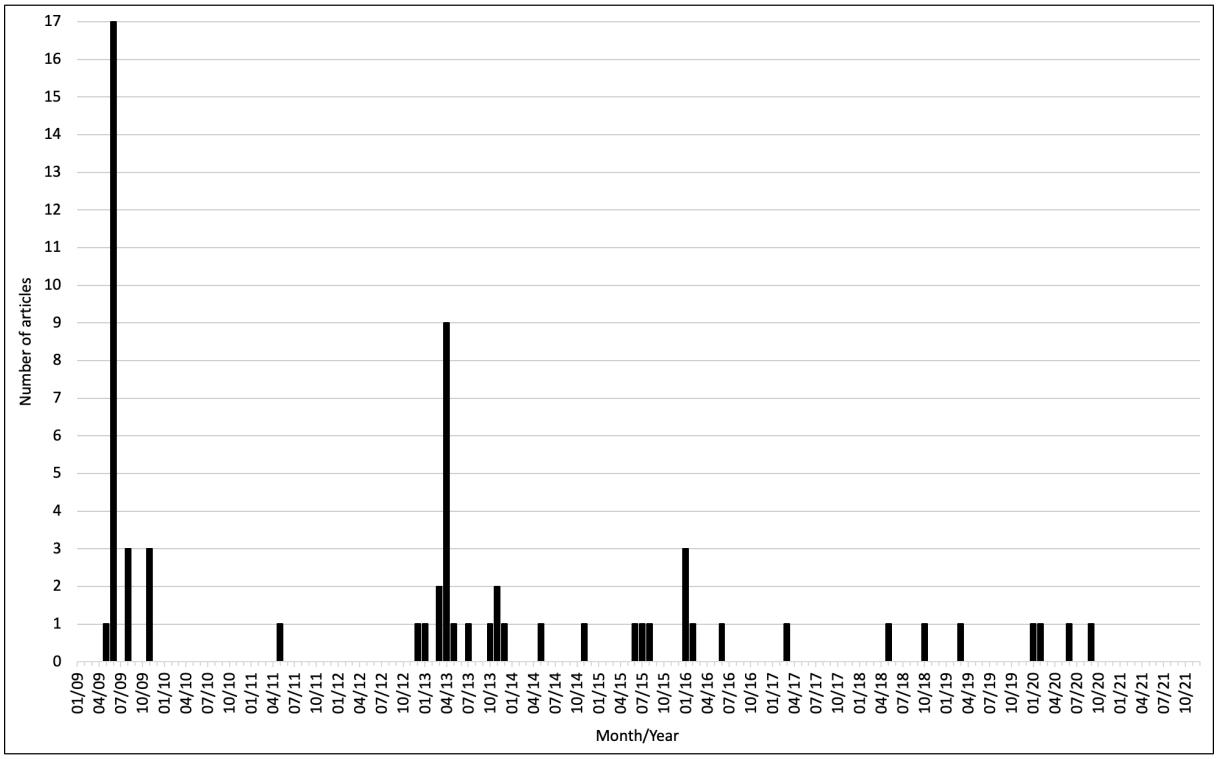

Figure 2: Timeline showing the number of press articles mentioning the E-PRTR published every month since its first data publication. The peaks occur mainly at the time of first data release (June 2009) and the publication of reports by Greenpeace (2013) and Ökopol (Tebert, 2015), with only few isolated articles in between. Depiction my own, based on data from NEXIS, Genios, and ProQuest databases.

Since the first publication of E-PRTR data in 2009, 62 press articles mentioning the register have been published in nine national and 21 local German newspapers and news magazines (Table 4). Almost a third of those articles were short notices of 200 words or less. Almost all articles were published with an external occasion: The first publication of the E-PRTR, a third-party report, or a current local issue. Only a third of articles use E-PRTR data themselves. Half of the articles highlight the fact that the register is publicly accessible or provide the URL to the website, creating public awareness of the universal access to the tool. In 2010 and 2021, there was not a single press publication mentioning the E-PRTR, and in each of 2011, 2012, 2017 and 2019, only a single article appeared (Figure 2). Considering the span of 13 years, the clustering of articles as outlined below, the large number of short reports, and compared to the amount of press coverage of the TRI, this can be interpreted as a very small number, indicating a low degree of press publicity created around the register.

Table 4: Categorisation of press articles mentioning the E-PRTR.

Type	Number of articles	Local newspapers	National newspapers	Accessibility highlighted	Short notice	Negative headline	Mentions company
Coverage of E-PRTR	26	15	11	20	16	4	4
Local issue	12	8	4	3	1	6	10
Blacklist	8	6	2	7	0	8	8
NGO/research report	16	8	8	1	2	16	10
Total	62	37	25	31	19	34	32

Four types of coverage mentioning the E-PRTR were identified:

- Articles about the register itself,
- Articles about a local issue or specific facility,
- Listing of the worst polluters in a city or federal state (blacklist),
- Coverage of NGO and other research publications.

Coverage of the register itself, marked by articles with the main purpose of describing the E-PRTR, was concentrated in the days after the first publication of E-PRTR data on the German website (June 3rd, 2009). The press echo mainly occurred in the first half of June 2009 and included 15 reporting newspapers (six in the form of a short notice), among them two of the largest German national daily newspapers, Frankfurter Allgemeine and Süddeutsche Zeitung. There were three articles, none in the major newspapers, drawing attention to the publication of the full E-PRTR dataset on the European website in November 2009, and two publications related to the overhaul of the German register. Data publication in the following years did not receive press attention. The introduction of the E-PRTR was thus newsworthy to the press, but its further development was only covered to a low extent.

Eight articles have been published that **blacklist** the "worst" polluters in an area based on their absolute emissions, using terms such as "Stinker [stinker]" (Volgmann, 2014), "Dreckschleuder [mud slinger]" (Dietz & Sommer, 2013; Kaiser, 2009), or "Umweltsünder [environmental sinner]" (Tupeit, 2013). More than half of all articles used such negative language in headlines. Blacklists were compiled for five of the 16 federal states: Bayern, Berlin (twice), Hamburg, Brandenburg, Mecklenburg-Vorpommern (twice), as

well as the city of Nuremberg. Tagesspiegel, a Berlin-based newspaper, produced a map titled "Giftatlas [toxics atlas]" showing the amount of different pollutants released in the city by facilities (Hoffmann & Jacobs, 2013), and the respective article provides analysis on the significance of the pollution shown, as well as comparison with other sources. Most other articles are less comprehensive and mention examples of the biggest polluters of a few well-known pollutants. Given the scarcity of such reporting, and that, as some articles acknowledge in contrast to their headlines, absolute numbers are not sufficient to judge environmental impacts, potential "shock and shame" effects from press blacklisting using the E-PRTR are small.

There were few examples of the press using the E-PRTR data for a deeper analysis, e.g. through comparison of facilities and their environmental performance, or combination of data with other sources to investigate pollution. Also, with the exception of coverage of the Greenpeace (2013) report described earlier, little attention was paid to health impacts of pollution. This points towards a high barrier: Using the E-PRTR for analysis requires expertise and is time-consuming, while reporting worst polluters is comparatively simple. This type of coverage, however, risks distracting from smaller facilities with bad pollution records relative to their output (IV2).

In addition to some single mentions of other NGO publications, two of the **research reports** mentioned earlier that used the E-PRTR as an essential source drew significant press attention, with articles appearing in all major German newspapers. In these cases, two layers of analysis and information processing are performed before information reaches the wider public. This shows that if an additional intermediary is involved and draws conclusions from PRTR data, the media is inclined to amplify them.

The study on mercury emissions from coal power plants (Tebert, 2015) was covered by four newspapers with reference to the E-PRTR, as well as by several TV stations (Institut für Ökologie und Politik GmbH [Ökopol], n.d.). The Greenpeace (2013) study on deaths due to pollution from coal power plants was covered by eight newspapers, among them four national newspapers, with reference to the E-PRTR and detailed discussions of report conclusions. The industry reacted with denial, calling the conclusions misleading and claiming negligible health effects in the vicinity of power plants, based on official measurements (Handelsblatt, 2013). An industry association reacted similarly to an NGO study (Health and Environment Alliance, 2013) on the "true cost" of coal power (Wonnemann, 2013). This provides examples of industry reacting to pressure by challenging it.

A small number of articles, 12 in total, covering a **local issue** or focusing on a specific facility referenced the E-PRTR, mostly in the context of power plants. In these cases, E-PRTR data aided the press by providing an accessible, independent, official source on pollution. For example, a Berlin newspaper used E-PRTR data to refute the claim by a company that a waste incineration facility was practically climate neutral (Keller, 2020), while another outlined current emissions of a power plant to be converted into a waste incineration facility (Jacobs, 2020).

With respect to the types of facilities, pollutants, and companies covered by the press, the focus has been on coal power plants, which, by absolute numbers, are often the biggest emitters. Consequently, E-PRTR pollutants covered by the press include carbon dioxide, fine particulate matter (PM10) and sulphur dioxide (SO_2) emitted to air. Other pollutants that are highlighted include mercury, other heavy metals, and ammonia (NH_3). Most of the companies that are explicitly mentioned are utilities operating coal power plants: Vattenfall (14 times), RWE (10), E.ON (5), Uniper (3), EnBW (1) and MVV (1). 24 other private companies are mentioned once in the press, mostly as the biggest polluters of a specific type, among them both large industrial companies and local businesses and farms. Often, municipalities' own wastewater treatment plants appear as big polluters, showing the misleading character of absolute pollution numbers. Most facilities, industrial sectors and pollutants were not covered by the press in relation to the E-PRTR, which means less-known pollutants and sectors may be forgotten despite being important for environmental protection (IV3).

Hence, the E-PRTR's main contribution was not to uncover otherwise unknown pollutants and set issues on the agenda. Coal power plants and carbon emissions, for example, are addressed extensively by other data sources, regulations, and in the public and political debate. The E-PRTR was used due to its accessibility and comparability, providing data on the facility-level, and to report on topics of particular public interest. German press coverage of the E-PRTR has been very limited, centring around a few issues, regions and occasions, such as the first publication of the data. The large amount of secondary attention to E-PRTR data through coverage of reports suggests that if analysis is performed by experts and conclusions are drawn, the press is more likely to cover it prominently.

4.3.5 Publicly traded companies in the E-PRTR

There are some signs that E-PRTR data is used to inform investors through intermediaries. The U.N. Principles for Responsible Investment mention the E-PRTR and TRI as sources on waste production and for analysis (U.N. Principles for Responsible Investment [UNPRI], 2013, n.d.). ECO-OS, a consultancy firm, also includes PRTR data among its data sources to assess sustainability performance of companies (ECO-OS, 2020). Whether the E-PRTR is being used by the major environmental rating agencies is unknown due to their secrecy. MSCI, one of the biggest rating firms, mentions "toxic emissions and waste" along with carbon emissions among their key performance indicators for assessing companies' environmental performance, and uses specialised government and NGO datasets, as well as media monitoring (MSCI, 2020). Sustainalytics (2021) also uses "public disclosure, media and NGO reports" to compile their ratings, and EcoVadis lists NGOs, media, and the European Environment Agency as sources, too (Ecovadis, 2017).[13] Therefore, E-PRTR data, either directly, or indirectly, through media and NGO reporting, can be one source for investors to help gauge environmental performance.

When analysing the ownership of reporting facilities in the E-PRTR, however, most of them are operated

[13] All three ratings agencies would not answer whether they have used E-PRTR data in their analyses upon request.

Table 5: Publicly traded companies with facilities reporting direct pollutant releases to the E-PRTR in 2007. Most facilities belong to large power utilities, and most other companies are large industrial manufacturers.

Company name	Industry	Number of reporting facilities
BASF SE	Chemical	6
Bayer AG	Chemical	6
BMW AG	Cars	4
Daimler AG	Cars	5
E.ON SE	Energy	21
EnBW AG	Energy	6
HeidelbergCement AG	Cement	8
Heidelberger Druckmaschinen AG	Machine-building	1
Henkel AG & Co. KGaA	Consumer goods	1
Holcim AG	Cement	3
K+S AG	Mining	1
Mainova AG	Energy	1
MAN AG	Cars	3
MVV Energie AG	Energy	3
Norddeutsche Affinerie AG	Metal	2
Pilkington Deutschland AG	Glass	2
RWE AG	Energy	20
Süd-Chemie AG	Chemical	1
Südzucker AG	Sugar	10
ThyssenKrupp Steel AG	Metal	11
Verallia Deutschland AG	Glass	4
Volkswagen AG	Cars	7
Wacker Chemie AG	Chemical	2

by municipalities (e.g. water treatment plants), private persons (e.g. farms and small businesses), non-stock companies, or stock companies that are not publicly traded. 36 publicly traded companies were found reporting to the German E-PRTR for 2007, of which 23 reported direct releases of pollutants into the environment (Table 5), representing 128 of 1648 (7.8 %) facilities reporting such releases. 47 of these facilities were large combustion plants, mostly owned by the major utilities EnBW, RWE, and E.ON. The remaining facilities belong to large companies in the mineral, metal, chemical, and car industries. The presence of publicly traded companies in the German E-PRTR is thus limited to a few industrial sectors and its largest companies, including the energy sector, which was also the focus of NGO and press attention. Owing to the size of facilities, publicly traded companies contributed shares of over 25 % of PRTR-reported emissions in 2007 for 24 pollutants (Table 6), among them carbon dioxide, some heavy metals and air pollutants. For 23 pollutants, they contributed less than 25 % of reported releases, and not at all to releases of 17 pollutants. The energy sector was a major contributor to releases by publicly traded companies in some, but not all pollutants.

Table 6: Share of reported pollution releases from facilities belonging publicly traded companies. The relevant reporting year is 2007. Table shows the 24 pollutants with shares over 25 % and the share of releases from facilities in the energy sector for each. Table 8 in the appendix shows the remaining pollutants.

Pollutant	Share of total reported releases by publicly traded companies	Energy sector share of emissions by publicly traded companies
Anthracene	100%	0%
Ethyl benzene	100%	0%
Trichlorobenzenes (TCBs)	65%	0%
Lead and compounds	62%	3%
Fluorine and inorganic compounds	52%	95%
Phenols	48%	0%
Tetrachloromethane (TCM)	48%	0%
Mercury and compounds	47%	83%
Xylenes	45%	0%
Carbon dioxide (CO_2)	43%	86%
Nitrous oxide (N_2O)	41%	5%
Particulate matter (PM10)	41%	61%
Nitrogen oxides (NOx/NO_2)	39%	76%
Copper and compounds	39%	15%
Dichloromethane (DCM)	38%	0%
Chlorine and inorganic compounds	38%	95%
Fluorides	38%	31%
Arsenic and compounds	32%	52%
Naphthalene	32%	0%
Sulphur oxides (SOx/SO_2)	29%	74%
Carbon monoxide (CO)	28%	12%
Toluene	27%	0%
Chromium and compounds	26%	3%
Cadmium and compounds	25%	18%

Given the size of their operations, and users' inability to judge environmental performance from the data, the data publication in the E-PRTR itself is unlikely to represent decisive information to investors.[14] Also, most facilities and pollutant releases in the German E-PRTR are not related to publicly traded companies, unlike in the case of the TRI, limiting the potential of pollution reduction through financial markets. These results are important, since much of the literature that tries to trace such effects of PRTRs uses the stock price effect due to its quantifiable nature. As the use by rating agencies exemplifies, however, E-PRTR data can be one ingredient to affect company reputation. Strikingly, coal power plant operators are both targeted most by NGOs and media and represent the major group of facility owners that are publicly traded. Thus, they were most affected by public scrutiny in relation with the E-PRTR.

[14]The chemical industry association in Germany even communicates E-PRTR data proactively in its sustainability report (Verband der Chemischen Industrie e.V., 2021).

4.3.6 Reflections

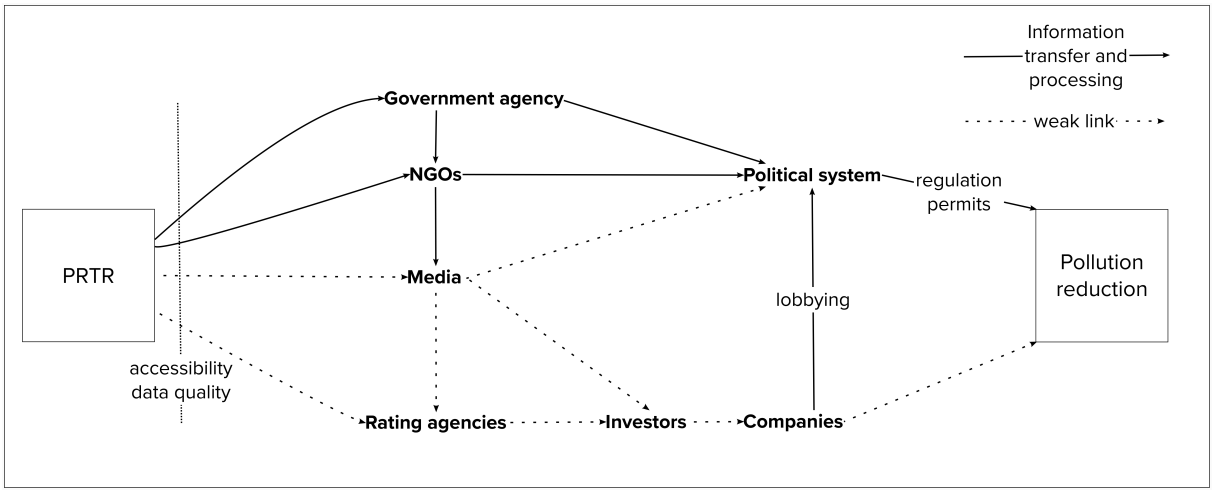

Figure 3: Stakeholder map depicting an updated version of Figure 1, taking empirical results into account. Depiction my own.

Reviewing the empirical results against the theoretical framework developed earlier, some updates are necessary (Figure 3). In the case of the E-PRTR, data accessibility and scope are major barriers for data use by all stakeholders. The first layer of processing is thus mostly done by experts on behalf of NGOs and government agencies. The media take up and amplify such analysis in prominent cases, but play a smaller role than expected and mostly report on such occasions. The E-PRTR did not remain entirely unnoticed, but did not become regularly embedded in advocacy work, NGO and press publishing.

Industrial pollution reductions involving local initiatives and NGOs are accomplished almost exclusively through influencing permit and standard-setting processes and thus, through authorities and the political system. This seems particularly effective when multiple intermediaries and impact analysis are involved: Technical experts and government agencies preparing reports, NGOs using them for campaigns and the media becoming aware to create publicity and political momentum. Such effects are visible in the case of the E-PRTR in Germany, but only to a limited extent. No convincing evidence points towards a significant effect of the E-PRTR compelling companies to voluntarily reduce emissions, compounded by the limited number of facilities outside the energy sector belonging to publicly traded companies, although there is some indication that E-PRTR data is used for sustainability assessment of investments.

Revisiting the dimensions of transparency and its role for transformation, PRTRs are mostly situated in the normative, providing data, and to some extent, in the procedural dimension, where actors are given a tool for their work. Except for a successful campaign to improve standards for mercury emissions, there was no tangible evidence, however, of a substantive impact on pollution.

Compared to other, more state-centric regulatory instruments, the reliance on intermediaries and voluntary action makes mandatory disclosure through PRTRs less effective. In particular, the ability and resources of NGOs, local communities, and especially the media, to create publicity and pressure

leading to change on the basis of PRTRs may be overestimated, according to the results on the E-PRTR. However, they can provide valuable information to support other mechanisms of pollution reduction. Mandatory disclosure has the potential to be more impactful if barriers are lowered, e.g. if data enables benchmarking and conclusions about environmental performance. The impact of mandatory disclosure is thus dependent on both the social and institutional setting, and on PRTR design.

5 Conclusion

With the introduction of the Toxics Release Inventory in the United States, mandatory disclosure of pollution data was greeted optimistically, as a new chapter in environmental regulation, stirring hopes of decentralised regulation through empowered civil society actors.

This study has investigated if and how the European Pollutant Release and Transfer Register has been used to impact industrial pollution in the German context through an analysis of press coverage, NGO work, and potential effects on the stock market. The collected evidence does not make for a compelling case that the E-PRTR has substantially contributed to preventing and reducing industrial pollution, contrary to assumptions from theory and official documents.

Findings suggest that the design and scope of the E-PRTR, e.g. its reporting thresholds and lack of supplementary data, are major barriers. Due to issues in data access, comparability and scope, its usefulness is limited to gaining an overview of the largest industrial polluters. Only few experts make use of the data, using it as one of many sources.

Hence, it is not surprising that press attention to the E-PRTR has been scarce and mostly covered large facilities and issues already on the political agenda, most prominently pollution by coal power plants. This also applies to NGO use of the data, which, in some cases, has sparked significant media interest and influenced the political process. Despite its limitations, the E-PRTR is a valuable complementary tool that has furthered transparency and provided a unique source of pollution data.

Exerting pressure on facility owners, leading to voluntary action, is assumed to be the main mechanism of pollution reduction through mandatory disclosure. This study, however, shows that addressing companies is not a promising approach in activism against pollution. In Germany, influencing permit processes and political lobbying for better standards are the main areas of civil society activity against industrial pollution. The E-PRTR has only influenced the latter to limited extent. Nonetheless, with some key changes, the register has the potential to be more effective in creating public awareness and action against industrial pollution.

On a more abstract level, mandatory disclosure through PRTRs should not be seen as an alternative to standards- or market-based regulation. Standard-setting is crucial for regulating industrial pollution. Intermediaries can, with the help of PRTRs, influence this process, but they should not be expected to become regulators based on mandatory disclosure.

The effect of PRTRs, however, depends on their design and the regulatory context, making this study specific to the E-PRTR and the European regulatory context. Further research could survey use and impacts of PRTRs in contexts other than the U.S. and Europe, and explore the ways in which industry decision-making reacts to public disclosure, which remained outside the scope of this study.

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Appendix

Table 7: Publication dates of E-PRTR data in Germany.

Reporting year	Publication date	Time after end of reporting year (full months)
2007	03.06.2009	17
2008	15.04.2010	15
2009	14.05.2011	16
2010	11.04.2012	15
2011	04.06.2013	17
2012	02.04.2014	15
2013	31.03.2015	14
2014	06.04.2016	16
2015	28.03.2017	14
2016	07.05.2018	16
2017	12.04.2019	15
2018	26.05.2020	16
2019	15.12.2021	23
2020	Not published as of May 7, 2022	>15

Table 8: Share of reported pollution releases from facilities belonging to publicly traded companies. Table shows the 41 pollutants with shares under 25 % and the share of releases from facilities in the energy sector for each. Pollutants for which no releases were reported to the E-PRTR in 2007 are not shown.

Pollutant	Share of total reported releases by publicly traded companies	Energy sector share of emissions by publicly traded companies
Cyanides	21%	0%
Nickelandcompounds	18%	22%
Non-methane volatile organic compounds (NMVOC)	17%	0%
Zinc and compounds	16%	2%
Benzene	16%	5%
Halogenated organic compounds	12%	0%
Octylphenols and Octylphenol ethoxylates	11%	0%
PCDD + PCDF (dioxins + furans)	11%	0%
Chlorides	9%	3%
Nonylphenol and Nonylphenol ethoxylates (NP/NPEs)	9%	0%
Trichloromethane	8%	3%
Fluoranthene	8%	0%
Ammonia (NH_3)	6%	4%
Total phosphorus	6%	0%
Polycyclic aromatic hydrocarbons (PAHs)	5%	0%
Total nitrogen	5%	7%
Hydrochlorofluorocarbons(HCFCs)	5%	0%
Total organic carbon (TOC)	4%	0%
Chlorofluorocarbons (CFCs)	2%	0%
1,2-dichloroethane (DCE)	2%	0%
Hydro-fluorocarbons (HFCs)	2%	0%
Hydrogen cyanide (HCN)	2%	0%
Sulphur hexafluoride (SF_6)	1%	0%
Methane (CH_4)	0.2%	65%
1,2,3,4,5,6-hexachlorocyclohexane (HCH)	0%	0%
Atrazine	0%	0%
Benzo(g,h,i)perylene	0%	0%
Di-(2-ethyl hexyl) phthalate (DEHP)	0%	0%
Diuron	0%	0%
Endosulphan	0%	0%
Ethylene oxide	0%	0%
Hexachlorobenzene (HCB)	0%	0%
Isoproturon	0%	0%
Organotin compounds	0%	0%
Pentachlorophenol (PCP)	0%	0%
Perfluorocarbons (PFCs)	0%	0%
Polychlorinated biphenyls (PCBs)	0%	0%
Simazine	0%	0%
Tetrachloroethylene (PER)	0%	0%
Trichloroethylene	0%	0%
Vinyl chloride	0%	0%