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Does the double diversion exist in the European Union?

An examination of disproportionality in industrial toxic pollution emissions

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Supervisor

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Abstract

The theory of the 'double diversion' is examined within the context of the European Union. The double diversion as originally proposed by Dr. William R. Freudenburg theorizes that few firms with privileged access to environmental rights and resources emit disproportional amounts of pollution while distracting attention so that they are rarely questioned about it. All EU facilities that reported emissions of toxic pollutants in 2008 were analyzed to look for levels of disproportionality in their emissions across and within different industries, compared to sales and employment data when possible. The results show a similar level of disproportionality compared to Freudenburg's results based on U.S. industries, providing evidence that the double diversion is not a phenomenon that exists only amongst industries operating in the U.S. Across all sectors the Gini coefficient for toxic emissions is 0.983, which means that just a small fraction of firms are responsible for the majority of all toxic emissions. Two individual facilities out of 9,976 accounted for 13% of all toxic pollution emissions in the EU in 2008.

Relevant EU and U.S. policies are discussed and compared in order to hypothesize how such disproportionate emissions can continue to be released in the countries with some of the strictest environmental regulations in the world. Recommendations are given for further research that would be valuable in the field of disproportionality, especially given certain regulatory changes that will take place over the next decade.

Keywords: Disproportionality, European Union, toxic pollution, double diversion

Executive Summary

The use of toxic substances in industrial manufacturing and processes throughout the world poses grave risks to human health and the environment, in the form of exposure to everyday products as well as exposure to industrial emissions of toxic pollution. All too often we learn the exact nature of the risks when employees develop symptoms of chronic diseases, or animal populations begin to mysteriously thin or display deformities. As it stands, scientific knowledge about the specific effects of chemicals is extremely limited: of the 100,000 chemicals known to be used in commerce today, only 7% of the 3,000 'high-production volume' chemicals have complete data available from toxicity screenings. For the rest of the 79,800 chemicals there is incomplete or no publicly available scientific knowledge about the risks they may pose to humans and the environment. The risk is multiplied when considering the synergistic effect any combination of these chemicals may have. The EU's REACH program has been implemented to attempt to address this problem, but the results remain to be seen. Until this critical data gap is filled, it is in our best interest to minimize or eliminate the production and use of these substances to the greatest extent possible.

Disproportionality theory

Freudenburg's theory of the 'double diversion' has two premises. The first is that some firms exploit privileged access to environmental rights and resources which results in disproportional harm to the environment compared to similar firms. The second diversion is that those firms who take advantage of disproportionate access to resources get away with it by diverting attention away from the matter to other distracting issues, such as jobs; this is possible because such industries are so widely expected to be economically "necessary" that they are rarely if ever questioned about their emissions patterns. He contends that this theory of disproportionality in toxic pollution emissions shows that high pollution levels are indeed *not* inherently necessary for certain industries, but rather are a result of outdated or inefficient technology, lack of innovation, or other factors. In the case of the highest polluting facility in the entire United States (U.S.), it turned out to be pure negligence: gypsum, a byproduct of fertilizer production, was being stored outside, washing massive amounts of phosphoric acid into the environment when it rained. Covering the gypsum and collecting the water runoff reduced the facility's toxic emissions by one-third (17,055,000 kg). The evidence for the double diversion adds to the growing body of evidence that environmental interests do not inherently counteract business interests by showing that in many cases the overwhelming majority of firms are emitting acceptable levels of pollution, with a few outlieing firms increasing average pollution levels within the industry astronomically.

Freudenburg analyzed data of toxic emissions across the U.S. from the U.S. Toxic Release Inventory (TRI), a database containing reports of emissions of 593 different toxic substances from thousands of facilities across the country. The results were groundbreaking. The statistics fully support the double diversion theory, showing that hugely disproportional amounts of toxic pollution were emitted by facilities in some of the least economically important sectors and that within those sectors, the highest polluting facilities typically do not employ a greater number of people or produce outputs at a level anywhere near to the level of their emissions output. In order to quantify the inequality of pollution emissions of all facilities across the board in the U.S., Freudenburg calculated the group's Gini coefficient, which is a statistical measurement of the distribution of inequality within a group, usually used to quantify the distribution of income within a given society. A Gini coefficient of zero represents a completely equal society, while a coefficient of 1.0 means that one actor within

the group controls all resources. Freudenburg calculated an staggeringly high coefficient of 0.755 for all facilities that emitted toxic pollution in the U.S.

Aim

As Freudenburg's study was just published in 2005, little other research on the double diversion has been completed to date. Without any other studies to compare it to, it was unclear whether or not the double diversion in U.S. industries was an American phenomenon, or whether it is indicative of industrial pollution patterns in other societies as well. Therefore the aim of this study is to determine the overall trends in disproportionality within and amongst industrial facilities operating in the European Union (EU). In order to investigate this, data was analyzed from the European Pollutant Release and Transfer Register (E-PRTR). A total of 9,976 individual facilities in 44 different subsectors reported releasing toxic emissions into water, soil, or air during the reporting year 2008. Several key statistical tests performed by Freudenburg to show disproportionality levels were replicated using data from the E-PRTR to the extent permitted by available data. The results are compared to Freudenburg's results to assess the level of disproportionality within EU industries, and to compare this to disproportionality in the U.S. As the E-PRTR has only existed in its current form since 2007, almost no academic studies have been conducted to analyze the reported emissions; this is in contrast to the TRI which has existed since 1987 and consequently has been thoroughly examined in various capacities, including for the double diversion. This is the only known study to investigate the double diversion in Europe. Policies and circumstances that may contribute to the double diversion are explored in order to attempt to understand the underlying factors that allow for this to occur.

Key findings & implications

The results show an astounding level of disproportionality both amongst different industries, which is to be expected to a certain extent, but more importantly *within* individual industrial sectors in the EU. The few major statistics found in this report indicate that in some cases there is greater disproportionality in toxic emissions in the EU than in the U.S. For example, the Gini coefficient calculated to measure the inequality of emissions across all 9,976 facilities included in this study is 0.983, far higher than Freudenburg's figure of 0.755 for U.S. industries. Freudenburg found that the top two highest polluting facilities within the chemicals industry in the U.S. produced 14% of all emissions from the chemicals sector and nearly 33% of emissions from the entire database. Similarly, EU data shows that the top two facilities from the chemicals sector produced 13% of all emissions from the chemicals sector and 32% of emissions from the entire database. The levels of disproportionality are comparable across the board.

The implications of the disproportionality theory are great, both for regulatory authorities and for the private sector. The framework of the double diversion provides an incentive for regulatory authorities to rethink the way that they craft environmental policies, and to which actors the policies are applied. For example, knowing that just 10% of facilities in a given industry are responsible for 65% of the toxic pollution, it makes sense to focus the most aggressive pollution reduction efforts on the minority of firms. The results of this study show that 10% of the facilities included in this study accounted for 98.4% of all toxic emissions in the EU in 2008. The top 1% of all facilities that reported toxic pollution releases were responsible for 85.4% of all such releases. While these statistics clearly show an extreme level of disproportionality, it must be emphasized that they are amongst sectors, not within, and that it was not possible to control for factors such as employment and production output that would give a much more accurate portrayal of disproportionality. Still, a more detailed examination of some of the results provides unmistakable evidence of the double diversion.

As the EU and some of its Member States are generally recognized as being leaders in environmental regulations it may be surprising to see the disproportionality statistics. The main current EU regulations governing toxic pollution are discussed, along with any conditions or loopholes that would permit such a high level of disproportionality. Since industries must comply with both national and EU-wide environmental regulations it is challenging to pinpoint exactly what legislation allows the double diversion to occur; national legislation is not considered in this report.

With this being the first study into this complex topic as it relates to the EU, further studies are needed to verify the trends in disproportionality as the E-PRTR releases data from the latest reporting years. As this provides an overall picture of the situation in the EU, it is recommended to undertake the study on a national level which will allow for a much more detailed and nuanced analysis. Ideally case studies of individual facilities will take place in order to investigate the precise causes of disproportionality on-site, as opposed to hypothesizing about a facility based on numerical data. As evidence of the double diversion grows, there will be a greater impetus to use it as a powerful and efficient regulatory tool.

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Abbreviations

BAT	Best available techniques
BFR	Brominated flame retardants
BPA	Bisphenol A
BREF	Best available technique reference (report)
EC	European Commission
ECHA	European Chemicals Agency
EEA	European Economic Area
EFTA	European Free Trade Area
EMT	Ecological modernization theory
E-PRTR	European Pollutant Release and Transfer Register
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPER	European Pollutant Emission Register
EU	European Union
EU-15	The Members States of the European Union prior to the accession of 10 candidate countries in May 2004
EU-27	The 27 Member States of the European Union as it stands currently
GDP	Gross domestic product
GNP	Gross national product
IPPC	Integrated Pollution Prevent and Control
Kg	Kilogram
LPH	Local pollution havens
PCB	Polychlorinated biphenyl
REACH	Regulation for Registration, Evaluation, Authorisation and Restriction of Chemicals
RSEI	Risk-Screening Environmental Indicators
TRI	Toxic Releases Inventory
TSCA	Toxic Substances Control Act
TURA	Toxic Use Reduction Act
UNECE	United Nations Economic Commission for Europe
US	United States

1 Introduction

Even those who are unaware of or uninterested in the modern environmental movement are likely to be aware of the pollution around them, or some way in which pollution affects them. Although today the media inundates us with the latest reports on climate change and how to reduce our "carbon footprint" from carbon dioxide, in reality there are thousands of pollutants that have an effect on everything from the air we breathe, to the water we drink and bathe in, to the soil where our food grows. The term 'pollution' encompasses many different things, from non-toxic greenhouse gases, to highly toxic heavy metals, to noise and even light pollution. All of these types of pollution are a fact of modern life for people in all corners of the world, yet some types are more harmful than others. In particular, pollution of toxic substances exposes humans and the environment to substances which can lead to grave effects, such as chronic disease.

People and ecosystems are exposed to toxic chemicals in different ways; people may often be unaware that they are being exposed to harmful substances even when they are inhaling, ingesting, or absorbing them into their skin. We are exposed to the products we use that contain chemicals, which include cleaning products, fabrics, carpeting, children's toys, furniture, electronics, building materials, food containers, and more (Environmental Defense Fund 1998). Furthermore we are also exposed to the pollution from the manufacturing of the chemicals themselves, as well as the manufacturing of the products using the chemicals. The effects of toxins on human health are not well documented to say the least, which is why legislation to regulate the use and emissions of specific chemicals if often reactive, rather than preventative (American Academy of Pediatrics 2011; Plant, Bone, Ragnarsdottir & Voulvoulis 2011; Grandjean et al. 2004). With so much focus on researching and regulating greenhouse gas emissions in order to mitigate the effects of climate change, it is important to keep the attention on toxic pollution which can have far more dire, immediate effects on humans and the environment.

For example, reports recently came to light that plastics used in baby bottles contain the chemical bisphenol A (BPA), which has been linked to a variety of very serious health complications such as cancers, diabetes, hyperactivity, early onset of puberty, impaired immune function, and problems in reproductive and neural development (vom Saal & Hughes 2005). Based on the evidence that amassed over the past few years, the European Union (EU) has voted to ban the import and sale of baby bottles containing BPA beginning in June 2011 (BBC 2010). Efforts by activists to enact a similar ban in the United States (U.S.) remain underway. Still, this is just one of many examples around the world of new evidence about a chemical's toxicity prompting investigations, recalls, new regulations, or other actions to protect the public. The looming question always remains: which products that we use in our everyday lives will be behind the next big chemical scare? Although the focus of this report is on the manufacturing and emissions of these toxins, most people are unaware of the effect of those processes on individuals; cases such as the BPA highlight the personal consequences of these chemicals being in our household products and the environment.

1.1 The significance of toxic pollution

A report by the Environmental Defense Fund (1998) found that 78% of the chemicals used in the highest volumes had no public data available regarding any kind of basic toxicity tests. In the U.S. alone, there are 80,000 chemicals known to be used in commerce, 3,000 of which are "high-production volume chemicals" meaning that they are imported to or produced in the U.S. in quantities greater than one million pounds (453,592 kg) per year (American Academy of Pediatrics 2011). The U.S. Environmental Protection Agency (EPA) reported that 43% of the 3,000 high-production volume chemicals have no basic toxicity data whatsoever, meaning that zero information is known about the harm they are liable to cause to humans or the environment (EPA 1998). Fifty percent of such chemicals have incomplete toxicity screening data available, while only 7% of the 3,000 chemicals used in volumes greater than one million pounds per year have complete toxicity data available (EPA 1998). In what can hardly be a coincidence, the U.S. Occupational Safety and Health Administration mandates workplace exposure limits to only 7% of the same 3,000 high-volume chemicals (Wilson, Chia & Ehlers 2006). It is estimated that 1900 people in the state of California alone are diagnosed with a deadly, chronic, but preventable disease due to chemical exposure in the workplace *each month* (Wilson et al. 2006). When extrapolated to the entire U.S. population, this amounts to approximately 16,300 diagnoses per month, or nearly 200,000 per year.

It is estimated that there are 100,000 different chemicals used in commerce in the EU (Eurostat 2010). Just 14% of high-production volume chemicals have full "base-set" data on toxicity available; 65% have incomplete data (base-sets); and 21% have no toxicity data whatsoever (EEA 2007). Fortunately this is set to change under the EU's REACH legislation which is the most comprehensive attempt worldwide to research and catalog most chemicals used in commerce in the EU (see Chapter 4 for details). An issue of further concern is the synergistic effect that any combination of these toxins may have when compounded within the human body or the environment (Plant et al. 2011). In fact, 22% of workers in the EU report being exposed to toxic vapors (Eurostat 2010). In 2007 it was estimated that 74,000 people die in the EU each year as the result of diseases caused by exposure to dangerous chemicals in the workplace – deaths that could be reduced or prevented by reduced exposure to chemicals (Eurostat 2010). One could blame this on lax regulations that do not sufficiently protect workers, but regulatory officials can hardly be expected to craft laws based off of non-existent scientific evidence.

There are simply too many thousands of different chemicals and compounds to know how they affect each part of the human body or different components of ecosystems. In April 2011 the American Academy of Pediatrics published an editorial imploring the U.S. government to revise chemical policy in the U.S., specifically in order to better protect pregnant women and children. Figure 1-1 shows the distribution of toxins detected in parts of the human body such as tissue, blood, cord blood, and breast milk in a study done by the U.S. Centers for Disease Control and Prevention. When lacking proper scientific knowledge it is best to the use the precautionary principle, which in this case would mean reducing our use and emissions of toxic materials to the greatest extent possible when the effects of exposure are unknown.

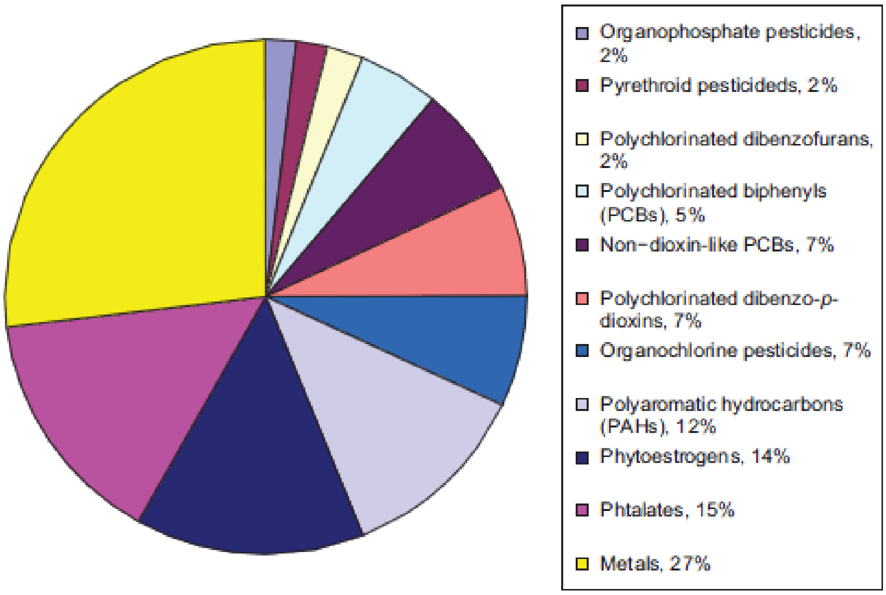

Figure 1-1. Distribution of toxins found within the human body. Source: American Academy of Pediatrics 2011.

The effects of toxins on the environment are similarly lacking in documentation. For example, the toxic effects of DDT only became well known and widely publicized following the publishing of Rachel Carson's book "Silent Spring" which many people mark as the catalyst for the beginning of the modern environmental movement (Plant et al. 2011). Many people may be able to recognize that substances like lead and mercury are harmful when released into ecosystems, but what about others like bis(2-chloroethyl) ether or hexamethylphosphoramide? Again, according to the European Environment Agency "we simply don't know how they [most chemicals] pass through the environment, whether they are accumulated, dispersed or transformed, and how they affect living organisms at different concentrations" (EEA 2011). The latest report on the state of the environment in the EU declared that "new problems are appearing, resulting from exposures to low levels of an increasing number of chemicals, often in complex mixtures" (EEA 2007, p.126). At the same time, increased scientific knowledge is beginning to highlight new risks arising from "old" pollutants.

The U.S. EPA has predicted that between 2006 and 2033 about 600 new hazardous waste contamination sites will appear each month in the U.S. in addition to the 77,000 known contamination sites. The expected mitigation costs are around $250 billion (Wilson et al. 2006). Thus although governments do not want to be seen as taking an 'anti-business' posture when introducing environmental legislation, the numbers show that it is clearly in their interest, as well as that of the public, to regulate mitigate the effects of pollution on human health, the environment, and the economy as much as possible via regulations.

Despite these worrying facts, global chemical production is expected to double every 25 years with no foreseeable end in increases (Wilson et al. 2006). The global trade in chemicals increased by an average of 14% per year between 2000 and 2005 (WTO 2006). In the EU between 1995 and 2005, production of toxic chemicals increased by 23.5%, while production of the most dangerous chemicals including carcinogenic, mutagenic, and repro-toxic chemicals increased by 22% (EEA 2007). Figure 1-2 shows the pattern in EU chemicals production between 1996 and 2008.

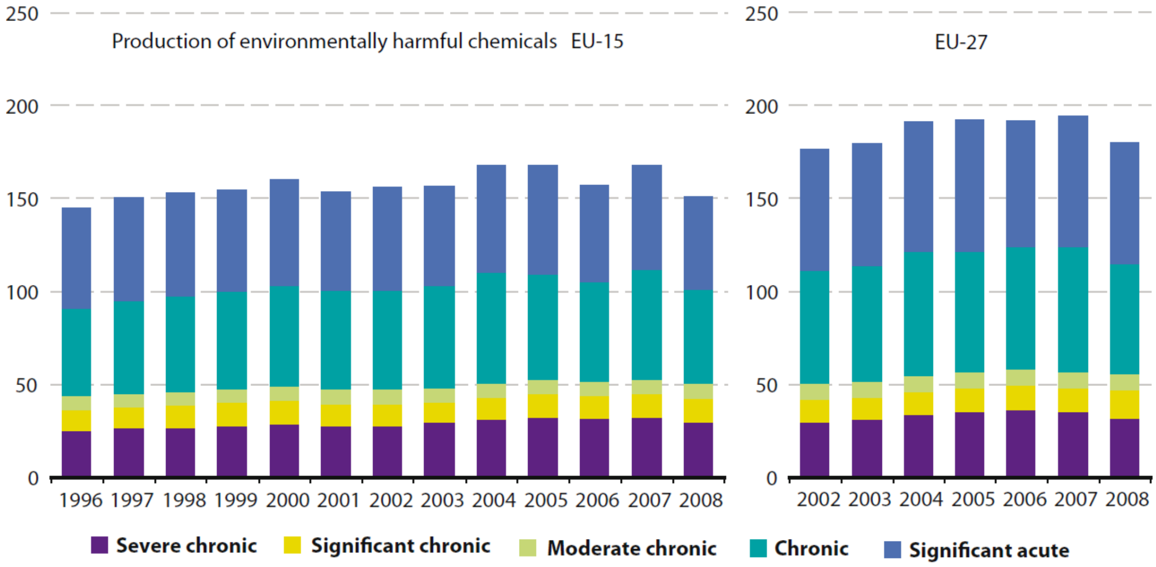

Figure 1-2.Timeline of the physical volume of production of environmentally harmful chemicals in the EU-15 and the EU-27 (in million tonnes). Source: Eurostat 2010.

The underlying message of all of this data, or rather lack of it, is that it is very much in the interest of humans and the environment to minimize the use of toxic chemicals to the extent possible. Innovation and regulation are the two key ways of realizing this goal; both topics will be discussed further in the following chapters. However it suffices to say that innovating new technologies and implementing them on a scale large enough to make a noticeable difference is a gradual process that does not provide any relief in the short or medium-term. Research and regulation by government agencies is therefore imperative, not only to protect humans and the environment from excessive or unnecessary amounts of toxic chemicals, but also to provide or increase the incentive to innovate. Unfortunately government legislation that imposes regulations on the business sector for the purpose of protecting the environment is often subject to fierce backlash from powerful corporate lobbies. The debate about the dichotomy between the environment and the economy has raged on for decades, with little change in the rhetoric (Repetto 1995; Matthews 2011). Yet there is a small body of growing evidence that provides a new perspective from which to approach regulation of the use and subsequent pollution of toxic chemicals.

1.2 The double diversion

Dr. William R. Freudenburg dedicated his career to providing compelling evidence against several widespread, ingrained "truths" about the environment. One such myth that he worked tirelessly to dismiss was the idea that there must be tradeoffs between the environment and the economy. Unfortunately Dr. Freudenburg succumbed to his battle with cancer in December 2010. However, in an unfinished book chapter authored during the last year of his life, Freudenburg wrote the following (Freudenburg 2010, p.1):

> *"Last night, I found out that I may have a rare and usually fatal cancer, meaning that I don't know how much time I have left on this earth. This morning, I decided that one of the things I want to do with that time is to finish this book about the earth, and about what we humans are doing to it. I have spent about thirty-five years in studying relationships between humans and the environment. For at least half of that time, I have been increasingly bothered by an assumption that seems to permeate almost all environment-society writing — and that is clearly wrong. My goal, during whatever time I*

> *have left, is to spell out the reality of the situation as clearly as I know how. That assumption goes by several names, which will be spelled out more fully in the following pages, ranging from "the Tragedy of the Commons" to the "IPAT equation." The common theme through all of them is the assumption of rough proportionality between levels of environmental harm and levels of economic activity – that there are too many of us and that we all use too much."*

Freudenburg goes on to say that the purpose of the book is to "let out the truth about a little-known secret", which he explains is that the economic importance of the most environmentally harmful activities is "almost vanishingly small" (Freudenburg 2010, p.1). While news clips and public education campaigns urging each individual to reduce his or her environmental impacts have become commonplace, Freudenburg posits that the greatest reductions in pollution can be achieved by targeting a very select few industrial actors, as opposed to the sum of minute changes in the behavior of millions of individuals.

While researching toxic releases during the 1990s, Dr. Freudenburg noticed that certain sectors of the American economy consistently produced dramatically more toxic emissions than other sectors; this finding is not hugely surprising, given that it would be unreasonable to expect every industry to produce similar amounts of pollution. However Freudenburg took it one step further, to examine the toxic releases *within* these individual industries or sectors of the economy and found that certain firms produced emissions far above the average level for the sector in question – even when the size of the facility was controlled for, in terms of the number of employees or the output of products (Berry 2008). Again, it is not reasonable to expect that every company within a given industry would operate at the same or comparable level of efficiency, but the statistics that Freudenburg calculated cannot be explained by simple differences in efficiency between firms; the levels of disproportionality are simply too great.

In 2005 he published the pioneering study on his Disproportionality Theory titled "Privileged access, privileged accounts: toward a socially structured theory of resources and discourses" in which he exposed truly astounding statistics that result from a phenomenon he called the "double diversion". The fundamental basis of his theory is that environmental harms involve two forms of privilege, together known as the double diversion. The first is the privileged diversion of environmental rights and resources, resulting in disproportional pollution emissions. Contrary to common belief and arguments, the majority of environmental harm is not "economically "necessary", but rather "represents privileged access to the environment" (Freudenburg 2005). This disproportional environmental damage is made possible with the help of the second diversion, which is the diversion of attention, or distraction, which diverts attention away from the disproportional harm.

The data presented in Freudenburg's 2005 study shows that "rather than producing advanced materials, major polluters tend to be inefficient producers of low-value commodities, and rather than being major employers, they can have emissions-to-jobs ratios a thousand times worse than the economy as a whole" (Freudenburg 2005, p.89). This data will be discussed in depth in Chapter 2; however just one example of the statistics found by Freudenburg is that approximately 60% of all toxic emissions in the U.S. were from just two industrial sectors, chemicals and primary metals, which together account for less than 5% of the nation's gross national product (GNP). The disproportionality becomes stunningly clear when it is revealed that together these industries account for just 1.4% of jobs in the U.S., resulting in a disproportionality ratio of 20:1 (Freudenburg 2005). Scorse (2000) found similar results in his analysis of the TRI; as seen in Figure 1-3, he found that the top 10% of polluters in U.S. states were responsible for approximately 55% of the toxic pollution.

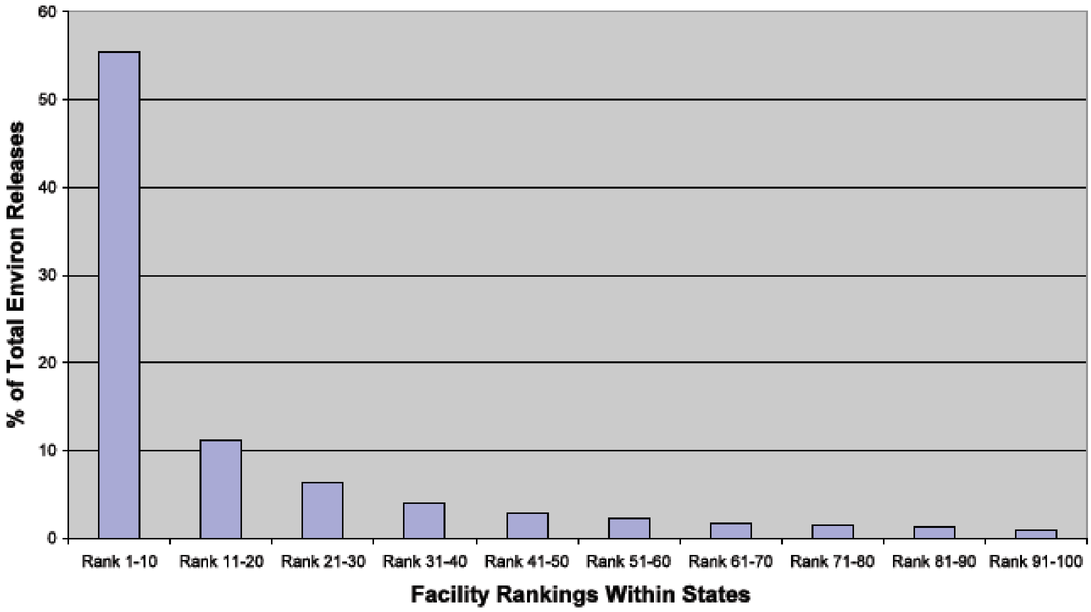

Figure 1-3. The percentage breakdown of total U.S. TRI pollution emissions by facility rankings across states, 1988-1997. Source: Scorse 2000.

Freudenburg's data provides convincing evidence that basing regulations for pollution emissions on average emissions data is not only misleading, but inefficient. Aggregated environmental figures such as the "Ecological Footprint" are an example of statistics that are widely used in policymaking, but do not take into account variations within the often massive groups on which the data is reporting. For example, ecological footprints claim to report the per capita environmental impact within the group in question, yet in reality the footprint is determined by calculating the sum of the environmental effects divided by the number of people in the group. In other words, an average is calculated in order to report the footprint for a group or society on a per capita basis; not only do such figures conceal within group variations, but growing evidence shows that using averages to report resource use results in an overestimation of the typical usage by the majority of individuals or firms within a group (Berry 2008; Freudenburg 2005, Nowak & Cabot 2004; Nowak, Bowen & Cabot 2006).

The implications of such statistics are widespread; however bringing awareness to the double diversion holds great significance in the policy realm. According to Berry (2008), if similar patterns continue to be found in future research focusing on disproportionality, this would signal that the "widespread "Proportionality" hypothesis – the assumption that underlies most between-group comparisons of resource use and pollution production" significantly inflates the amount of pollution that should be assumed for a given level of industrial output (p.262). In other words, more comprehensive research that shows proof of disproportionality within industries would force regulatory agencies, community members, production engineers, and a whole host of stakeholders to reevaluate the "necessary" level of pollution for a given level of output as opposed to what the per capita figures say. Thus, in cases of industries that display log-normal distributions of pollution production, regulations that specifically target those firms releasing highly disproportional levels of pollution are likely to reduce the industry's overall pollution levels at a greatly reduced cost compared to regulations that mandate pollution reductions in equal increments across all firms (Berry 2008).

Beyond the regulatory implications, the double diversion sheds new light on the classic debate between the economy and the environment by showing that there are plenty of firms that are able to compete within the same industries with relatively proportional ratios of jobs to pollution, pollution to output, etc (Freudenburg 2005; Berry 2008). Still, the 'jobs vs. the environment' debate has not waned despite growing concern for global environmental issues such as climate change and ozone control. An article published in the New York Times on March 16, 2011 summarized the "historically large cuts" that conservative governors in various U.S. states are seeking to make to state-level environmental regulations and budgets for environmental protection. In a radio address Governor Paul LePage of Maine provided a typical argument in this debate: "Maine's working families and small businesses are endangered," he said. "It is time we start defending the interests of those who want to work and invest in Maine with the same vigor that we defend tree frogs and Canadian lynx". On a similar note, the spokesman for Florida Governor Rick Scott explained that the governor "does care about the environment, but feels it is more important to get people back to work." (Kaufman 2011). These types of statements have become so ingrained in corporate and political discourses that it is challenging at best to introduce any evidence to the contrary in order to change what has long been widely accepted as fact. This discussion continues further in Chapter 2 and Chapter 4.

1.3 Research questions

As the pioneering article on the double diversion was only published in 2005, little subsequent research has been done so far. To Freudenburg's knowledge, the double diversion has never been explored within the context of European industries. Thus, the aim of this paper is to assess the level of disproportionality in industrial emissions of toxic substances within EU industries. Freudenburg believed that this thesis would be "the first to extend the concept to a whole new continent, and one where at least quite a few folks would argue that the idea shouldn't work as well, since EU regulations are often more effective than those in the U.S" (W.R. Freudenburg, personal communication, November 2010).

Therefore, the appropriate research questions are as follows: Does the double diversion occur within and across industries in the EU? To what extent do the results compare with Freudenburg's study of U.S. industries? What conditions in the main EU pollution legislation can be correlated with the level of disproportionality in Europe found in this study, and what implications could the results have for future policymaking in the EU? While both components of the double diversion theory are worth examining, this study will mainly focus on the first diversion, the "privileged diversion of rights and resources", as the second diversion, related to distraction of attention, is more closely related to Freudenburg's field of sociology.

While the U.S. is often chastised for its high rates of consumption and lack of action in global environmental forums, the EU on the other hand is often at the forefront in advancing and promoting environmental policies and technologies; Germany for example is aiming to double raw material productivity by 2020 as compared to 1994 (Walkowiak et al. 2008). Therefore although one could never expect to find disproportionalities as striking as Freudenburg's statistics reveal, the U.S. is known for having strong corporate lobbies that are often successful in promoting business interests over environmental ones, which may make the double diversion statistics less surprising for some (Keleman & Vogel 2009). In fact, while the U.S. emerged as the original lead in the environmental movement during the 1970s, the EU has taken the lead since the 1990s, essentially swapping positions in international leadership of environmental issues. Since 1989 the U.S. has ratified only two important environmental agreements while the EU has signed and ratified 12 (Keleman and Vogel 2009). The results of this study will bring us one step closer to understanding whether or not the double diversion is an anomaly to be found only within U.S. industries, or if it is a more widespread phenomenon across other similarly developed economies such as the single market formed by the EU and members of the European Free Trade Association[1] (EFTA).

This structure of this report is as follows. Chapter 2 describes the double diversion and the results of Freudenburg's 2005 study in further detail, as well as frames the literature on the jobs versus the environment debate within the context of the growing evidence on disproportionality. Chapter 3 contains the methodology and results of the statistical analysis of toxic pollution emissions in the EU that was performed in order to determine the level of disproportionality in the EU as compared to the US. Chapter 4 discusses the results and further examines the data on the level of disproportionality in the EU. EU policies are analyzed in order to pinpoint policies that may have an influence the level of disproportionality. Chapter 5 concludes the report.

1.4 Limitations

There are many different bodies of literature and statistical analyses that could be used in this report, therefore it provides only a limited overview of the array of topics that could be covered in relation to the double diversion in the EU. The literature review concentrates on some related studies on the economy versus the environment debate, while the theoretical background focuses on two key theories: the treadmill of production and the ecological modernization theory. These are two of the most widely discussed theories about industrial production and the environment over the past several decades and provide two different perspectives from which to understand the double diversion. There are many studies on different aspects of environmental management in production processes, the benefits of eco-efficiency, the economic effects of environmental regulations, etc. which could not be covered. Instead, select studies which provide an overview of relevant facts and evidence were chosen for inclusion.

The limitations specific to the statistical analysis are discussed in the Methodology section of Chapter 3; the organization of the E-PRTR was the main limitation in this respect. The analysis of policies related to the double diversion in Chapter 4 only covers the few main pollution policies that govern industrial facilities in the EU and the U.S. There are too many thousands of individual regulations, both at the national and the EU level, to consider anything besides the main ones at this time. As this report provides a broad overall analysis of the state of the double diversion in the EU, any future studies could use the foundation laid here to examine more specific policies and statistics.

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[1] The single market referred to is known as the European Economic Area (EEA). Formed in 1994, it is an international trading and economic organisation that facilitates free trade and works closely with the EU; all EU Member States are required to join the EEA. Currently there are 30 EEA members: the EU-27 Member States plus Norway, Iceland, and Lichtenstein.

2 Literature Review

2.1 An exploration of the 'double diversion'

The average person could probably think of some rational reasons why different companies within the same sector would have varying levels of toxic emissions. Accordingly, reviewers of Freudenburg's study presented him with four major concerns which must also be presented here in the context of this related study. First, the reviewers wondered if it would be possible to compare the disproportionalities of toxic releases with other forms of societal inequality. Freudenburg addressed this by calculating the Gini Coefficient for different economic sectors, which has also been done for this study (see the Results section in Chapter 3). The Gini Coefficient is used to quantify the degree of inequality of the income within a society. A completely equal society would have a coefficient of 0.0, while a society where all resources are controlled by one individual would have a coefficient of 1.0. According to the latest data from the CIA World Factbook, the U.S. has a coefficient of 0.45, ranking it as the 40th least equal society for income distribution, while the EU's coefficient is 30.4, ranking it the 111th least equal society out of the 126 countries ranked (CIA 2011). The highest historical Gini coefficient on record for a country is for South Africa during the apartheid era, when the coefficient reached 0.72 (Freudenburg 2005).

When Freudenburg calculated the Gini coefficient for all of the toxic pollution emissions released in the U.S. in 1993 (measured in pounds), the result was a coefficient of 0.755. Although Gini coefficients are usually used as a measure of income inequality within a society, the results can be interpreted in the same way if you consider each individual facility and its emissions the same way you would consider an individual person and his or her income. Freudenburg's calculation of 0.72 for the distribution of U.S. facilities' emissions simply tells us that a small proportion of polluters are producing the majority of pollution. The Lorenz curve in Figure 3-5 in the Results section displays a visual representation of the Gini coefficient.

Second, the reviewers noted that although toxic emissions are reported by weight (in pounds or kilograms), the overall weight may not be highly correlated with the toxicity of the releases and the subsequent amount of risk they pose to people and the environment. To quell this concern, Freudenburg recalculated all of the emissions data reported in weight (pounds) in terms of toxicity using the EPA's Risk-Screening Environmental Indicators (RSEI) system. Although this resulted in a different industry being the top polluter (primary metals), the more significant result was that the disproportionality within industries became even greater when emissions were measured in toxicity. In this case the Gini coefficient was 0.865, and about 80% of all toxicity could be attributed to just 8% of industrial sectors (Freudenburg 2005). Calculating emissions in terms of toxicity is beyond the scope of this study, though it will be discussed further in the Recommendations section of Chapter 3.

The third point of concern was that an obvious explanation for the disproportionality within sectors could be due to varied levels of economic activity among producers. In response to this Freudenburg obtained data from the U.S. Census Bureau on the number of employees and the total annual payrolls for each economic sector that he analyzed in the TRI. The result of imposing the controls on the number of employees and the size of payrolls was in fact an increase in the Gini coefficients for the sectors in question. Figure 2-1 shows the Lorenz curves for the primary metals sector when normalized for employment and payroll expenditures. The original Gini coefficient for the sector was 0.789. When normalized for payroll expenditures the Gini coefficient grew to 0.817, and up to 0.821 when normalized for the number of employees. Therefore at least in this example, the differing size of industries was not the cause of the disproportionality in toxic releases. In fact, it increased disproportionality. Although payroll data was not available for EU industries, some of the data presented in the Results section in Chapter 3 does take into account other normalizing factors such as employment numbers and contribution to gross domestic product (GDP).

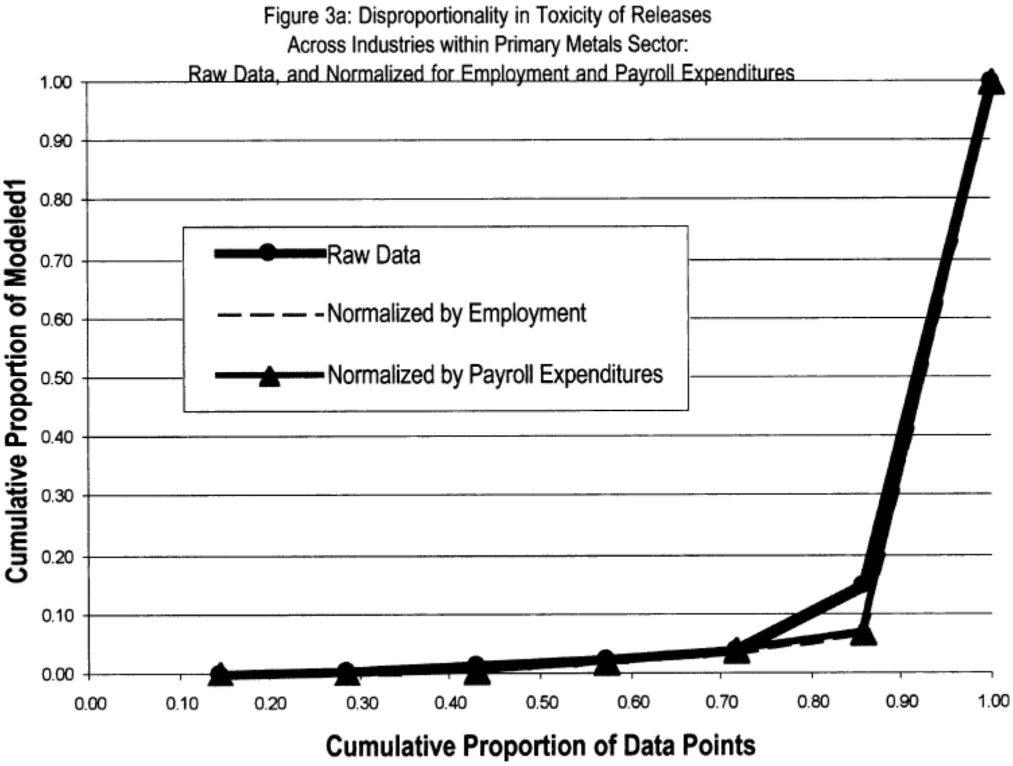

Figure 2-1. The Lorenz curve showing the disproportionality of toxic releases within the primary metals sector in the U.S. Source: Freudenburg 2005.

The fourth and final point brought up by the reviewers was whether some products simply require a disproportionately high amount of toxic pollution in the manufacturing process that is not possible to avoid with today's technology. Although this is a more valid concern when making comparisons *between* industries as opposed to *within* them, there are still some variations in the activities and types of manufacturing within industries. Given the evidence that the size of the facility or industry in question is not a factor in disproportionality, questioning the technological necessity is the next logical step.

Freudenburg approached this question within the context of the primary nonferrous metals industry, a subcategory within the primary metals sector, which was the most disproportionate industry in his study. Within this subsector, one facility out of a total of 62 produced 95% of the industry's total toxic emissions (due to a lack of data, Freudenburg could not apply further controls on this individual firm). The Gini coefficient for the primary nonferrous metals industry is 0.975; with the top polluting facility removed, thus removing 95% of toxic emissions from the calculation, the Gini coefficient falls back to 0.735, around the same level as the coefficient for the entire database (Freudenburg 2005). Although the one facility with 95% of emissions in this sector is in many ways an outlier, the extremely high Gini coefficient even when this facility is removed shows that this case is not an anomaly. For example, chemical company Freeport-McMoRan was one of the top polluting companies across all facilities in the entire U.S., yet even within the chemical industry its emissions-per-job ratio is 17.8 times as high as the industry average (1070:1 compared to 60:1) (Freudenburg 2005).

The common rebuttal upon hearing this information is to ask, 'Aren't these industries producing goods that are vital to the national economy?' In terms of jobs and dollars, Freudenburg (2005) says no: 60% of all toxic releases in the U.S. came from economic sectors that accounted for less than 5% of GNP and less than 1.5% of jobs in the entire country. It is essential to remember than the Freeport-McMoRan statistics above are calculated comparing emissions and jobs within the same sector. In this context, the argument that this sector may be producing goods that require an above average use of chemicals loses ground; even if this were true, it does nothing to explain the fact that one company *within* the same sector has a emissions to job ratio 17.8 times higher than the industry average.

2.2 Jobs versus the environment: tradeoff or myth?

The second half of Freudenburg's article is devoted to rebutting the classic arguments that imposing environmental regulations will force businesses to close or move overseas, both of which he rejects. Other scholars have come to similar conclusions. Matthews (2011) refers to the longstanding debate on jobs vs. the environment as "a choice or trade-off (either real or imagined) between economic growth and development on the one hand and environmental quality or lack of environmental degradation on the other" (p.60). He calls the need to balance environmental protection with economic growth "one of the central tensions in modernity" and identifies two reasons why the ongoing nature of this debate over the course of decades is "highly problematic for society". The first and most obvious reason is that the issues at stake behind all of the rhetoric remain unresolved. The second reason is that the debate simply heightens cultural and social divisions that reduce the potential for consensus-based democracy (Matthews 2011). Freudenburg (2005) sees this as a significant failure of environmental social scientists in gathering appropriate evidence and assessing it in an objective manner.

Inspired by Freudenburg's evidence of the double diversion, Matthews aimed to investigate the environment-economy dichotomy through the lens of local pollution havens (LPHs) in the U.S. LPHs are defined as areas (in this case, U.S. counties) that are characterized by high levels of pollutions with low regulatory controls and low levels of economic returns (Matthews 2011); all three characteristics must be met. Just over 6% of counties, 190 in total, met at least four of the nine economic and environmental criteria for being a LPH, while 74.28% of counties did not meet one single criterion. A host of interesting data was found about these communities, 91% of which are located in the southern region of the U.S. An example of such data is that the log median family income in LPHs is significant and negative, meaning that the economic status of the communities is likely to be below average; therefore, although the existence of the concentrated polluting firms provides a certain level of an economic boost, the local economy still suffers from an overall "dampening effect" (Matthews 2011). Although disproportionality and environmental justice do not necessarily go hand in hand, in this case the evidence speaks for itself: the percentage of African-Americans in LPH counties is more than twice that in non-LPH counties (Matthews 2011). By presenting empirical evidence of localized disproportionalities in both the environment *and* the economy, Matthews provides a stimulus to move beyond the traditional jobs versus the environment dichotomy. Although Freudenburg does not explicitly address the impact of disproportionately polluting companies on the surrounding communities, that is another area of disproportionality research that could provide significant insights into the human effects of the double diversion.

The 'Porter hypothesis' is considered to be one of the classic theories in this field. Porter and van der Linde (1995) argue that properly designed environmental regulations can stimulate innovations that actually lower the cost of a product or increase its value. In the end, this "enhanced resource productivity" gives companies a competitive advantage (Porter & van der

Linde 1995). They contend that pollution often constitutes a form of economic waste: when energy, byproducts, and scraps are released into the environment it is a signal that resources have been used ineffectively, inefficiently, or incompletely. While managers tend to focus on the real costs of treating pollution, instead they should account for the opportunity costs of pollution which include wasted effort, wasted resources, and ultimately a diminished product value to the customer (Porter & van der Linde 1995). The chemical industry, which is heavily discussed in the context of the double diversion, is one that seems to struggle with the perceived environment versus economy tradeoff. As evidence of their hypothesis, Porter and van der Linde point to a study of 29 chemical plants in which 181 possible waste prevention activities were identified that enhanced resource productivity. Of the 181 prevention activities, just one caused the company to incur a net cost increase. Sixty-eight of the activities showed increases in product yield. For each dollar spent on the prevention measures, companies saved an average of $3.49 annually. The Porter hypothesis states that regulations are needed in order to combat barriers to change such as the fact that managers have limited time and attention, and incomplete information regarding innovation possibilities; several case studies are cited where companies benefited from environmental innovations only after being forced to comply with EPA regulations.

In 2007 Cole and Elliott published the first country level analysis of industrial jobs versus the environment for a country other than the U.S, using data covering 27 industries from 1999-2003 to assess the impact of national environmental regulations in the UK on sectoral employment. In 2003 UK industry spent £3.4 billion on environmental protection measures, which amounts to 0.6 percent of industry revenue – interestingly enough, the burden of these costs falls upon the "traditional heavy industries" such as chemicals and basic metals, the very industries that Freudenburg found to be the most disproportionate emitters of toxic pollutants in the U.S. (Cole & Elliott 2007). Increased competitive pressures within these industries have lead to unions and industry representatives to call for an easing of environmental regulations in the UK. Indeed, in 2005 Sir Digby Jones, the Director General of the Confederation of British Industry, charged the UK government with "sacrificing UK jobs on the altar of green credentials" (Cole & Elliott 2007, p.1).

The study found that costs arising for industries as a result of environmental regulations in the UK are a statistically insignificant determinant of employment levels. They hypothesize that it is possible that the regulations have both positive and negative effects on employment which cancel each other out to show no effect. For example, output may decline slightly to comply with standards, thus requiring fewer employees, but abatement activities require additional employees. This is consistent with Repetto (1995), who concedes that "while jobs in particular industries may rise or fall, total employment will not be systemically affected" (p.22). Cole and Elliott (2007) caution that the study was greatly restricted by the limited data available in the UK in comparison to the U.S., which was also an issue in this study of EU data.

Further aspects of this debate will be discussed in Chapter 4.

2.3 Theories of production: the 'Treadmill of Production' and 'Ecological Modernization'

Berry (2008) poses the question, "Should we expect disproportionality?" In the search for the answer to this question the classic literature on the "Treadmill of Production" is examined in contrast with the concept of "ecological modernization" and growing evidence of the compatibility of environmental improvements with economic growth.

The concept of the "treadmill of production" was first introduced by Schnaiberg in 1980 in order to try to understand the rapid increase in environmental degradation in the U.S. in the second half of the twentieth century following World War II. The theory arose from two key observations: a) production processes were increasing their impact on the environment during the last half of the twentieth century, and b) the social and political response to the changing impact was "variable and volatile" (Schnaiberg, Pellow & Weinberg 2000). In essence, the theory states that there is an inherent conflict between economic growth and environmental protection – the constant pursuit of higher profits leads to increased production which escalates environmental harm in an unbreakable cycle. Berry (2008) found the arguments presented in the core literature written about the treadmill of production to be consistent with the expectation that environmental harm per unit of economic activity among producers of similar products should be relatively proportional. Of course in this case the levels of pollution would always be increasing incrementally with economic growth, as the treadmill of production does not allow for the possibility of decreasing emissions with growth.

The ecological modernization theory (EMT) contrasts the treadmill of production. Central to this theory is the belief that economic growth, capitalism, and technological development are not only compatible with increased sustainability but they may also be important drivers in environmental reform (York & Rosa 2003). The debate arising from the differences in the perspectives of the treadmill of protection theory and the EMT has been called "one of the more fundamental and central axes of debates in the environmental social sciences in the 1990s" (York & Rosa 2003, p.274). The two theories do share similarities, however. They both revolve around the processes the drive production and consumption, and the environmental disturbances that result from economic activity. Both theories also reject post-modern analyses, while seeking alternative organizational structures that provide better solutions for increasing sustainability. Their focus remains on the core aspects of modernity: capitalist production, the nation-state system, industrial organization, and science and technology (Mol & Spargaaren 2005). The double diversion is also inconsistent with this theory. Innovation and technological advancement are key facets of the EMT, which if anything should result in less disproportionality. Jänicke (2006) believes that ecological modernization "has by far the largest potential to achieve environmental improvements" however the current time there is a lack of marketable technological solutions for certain environmental problems (p.557).

Data confirms that certain pollution emissions in the EU fell between 1995 and 2006: in 2006, industries in the EU-25 were causing less environmental damage per unit of economic output than they were in 1995 (Eurostat 2010). Figure 2-2 shows the decrease in carbon dioxide emissions from EU industries over this period while gross monetary output simultaneously rose. According to Eurostat, during this period greenhouse gas emissions from EU-25 industries should have risen by about 41% in conjunction with the economic growth. Instead, citing changes in fuel use and technological development, emissions rose by less than 1%, proving that in fact the treadmill of production theory does not hold true (Eurostat 2010).

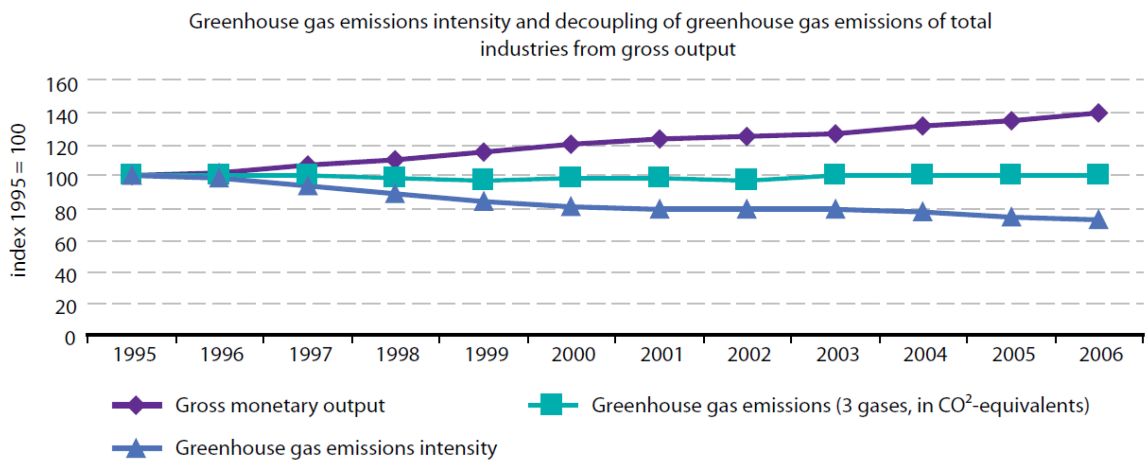

Figure 2-2. Greenhouse gas emissions from EU industries decreased between 1995-2006 while gross monetary output increased. Source: Eurostat 2010.

Research by Templet and Farber (1994) also rejects the notion that improving environmental conditions goes hand in hand with weakening economic development. Instead they found empirical evidence to suggest that increased environmental risk resulting in the reduction of an ecosystem's economic carrying capacity consequently leads to a reduction in the "long-term economic welfare secured from the ecosystem" (Templet & Farber 1994, p.154). This is based on the notion that the economic comparative advantage of a region is determined by its abundance of natural resources. Templet and Farber (1994) set out to answer the question of whether "environmentally risky activities" result in "more or less economic welfare" by studying the ratio of toxic chemical emissions to jobs (E/J), similar to part of Freudenburg's methodology in proving the double diversion. They found significant inverse relationships between relative environmental risk and various measures of economic welfare: between the manufacturing E/J ratio and disposable personal income per capita, and between unemployment rates and the emissions-to-jobs ratios categorized by US state. A positive relationship was found between the E/J ratio and the average percentage of people in poverty at the state level. In short, the study established a direct correlation between poor economic conditions and rates of toxic discharges, hazardous waste, and energy usage all measured on a per job basis. The correlation, of course, does not establish causation; it is possible that poor economic conditions facilitate tolerance of environmental risk (Templet & Farber 1994). Although the study focused on just one limited measure of environmental risk, toxic emissions, the results serve as a warning that using "environmentally risky activity" to promote economic development may not be the best approach.

2.4 Previous reviews on EU emissions registers

The European Commission (EC) has performed several formal and informal reviews of the European Pollution Emissions Register (EPER) and E-PRTR data following the release of the emissions information. One such review resulted in a Memo (EC Memo 04/234) issued by the EC in October 2004, based on data from the first reporting cycle of EPER in 2001. It should be noted that the EPER data includes only 12,000 facilities, 50 pollutants, and 56 economic activities compared to the E-PRTR's 24,000 facilities, 91 pollutants, and 65 economic activities (a full description of the EU's current emissions database used in the analysis for this study, the E-PRTR, follows in Chapter 3). The Memo simply presents the top few polluting companies (although it is unclear if they are actually companies or facilities) for each of

EPER's 50 pollutants, and provides the percentage of the pollutant emitted by that company along with the number of facilities the reported emitting that pollutant.

While this information is valuable in the case that regulatory agencies are seeking to control specific pollutants, a table from a pollution database that is sorted by pollutant will include companies or facilities from a diverse range of industries. As discussed, a certain level of disproportionality is to be expected *between* industries due to the countless different products and processes that produce pollution. It seems that by identifying the top polluters in each pollutant category, the EC had similar intentions to this report but failed to realize that pollutant groups are neither the most accurate nor effective way of identifying the most disproportionate polluters in the database. Although this report will also examine disproportionalities between different industries to an extent, the focus will remain on looking *within* individual industries and sub-industries in order to provide the most accurate means of comparing toxic emissions.

An informal review of the E-PRTR data from 2008 was published in October 2010 (European Topic Centre Air and Climate Change 2010). It consists mainly of a summary of the data and a comparison of the 2007 figures. However it does briefly address disproportionality. Like the Memo, this review also identified the top polluting facilities by pollutant, but narrowed it down further to releases to air, water, and soil by pollutant. The distribution for emissions of some pollutants like CO_2 and NO_x, which are not included in this study, is around 1% each for the top five polluting facilities. The top five facilities for other pollutants like SO2 and PM10 each had a greater share of the total releases, from between 2% to 10% (EC 2010). Other pollutants such as CH4 and HCB have reports of individual facilities with shares of 20% to above 50% of the total emissions in the EU, which is more consistent with the results found in this report. The EC report suggests that such findings should be further investigated by the Member States, and that it may be possible that emissions were reported in the wrong units.

The EC released a tender in September 2010 to award a contract for a comprehensive review of the E-PRTR data from 2007. This project has a 16 month timeline and a budget of €160,000; however the chief objective of the report is to assess the implementation, compliance, and accuracy of the database. There is no mention of topics specifically related to disproportionality in the tender.

The 2010 edition of Eurostat's "Environmental statistics and accounts in Europe" provides some valuable insights into the relationship between industries' emissions and measurements of their contribution to the economy, although it focuses on greenhouse gas emissions. The report notes that four economic industries that account for 43% of gross monetary output in the EU produce 84% of greenhouse gases, 93% of acidifying substances, and 81% of ozone damaging substances (Eurostat 2010). While this is certainly evidence of disproportional emissions, once again it is more useful to measure disproportionality within sectors rather than between them. In this case the service industry in the EU accounts for 57% of gross monetary output, however it is hardly fair to compare emissions from a service based industry to the manufacturing or transport industry. A disproportional distribution is to be expected in this case. Hence, rather than reproaching the transport industry for producing disproportional emissions compared to the service industry, it makes more sense to compare the transport industry to itself, or at least to industries with similar activities.

3 Methodology, Results, and Discussion

3.1 Background

The U.S. EPA maintains the most exhaustive public national pollution database in the world. Known as the Toxics Release Inventory (TRI) Program, it was created under legislation called the Emergency Planning and Community Right-to-Know Act (EPCRA) passed in 1986 that was inspired by the 1984 incident at Bhopal, India, which was followed by another serious chemical release event at a West Virginia chemical plant. One of the primary goals of the EPCRA is to allow citizens to be informed of chemical releases in their surrounding areas. Accordingly, Section 313 of the EPCRA requires the EPA to collect annual data on the releases and transfers of 593 toxic chemicals from industrial facilities, and to make the data available to the public through the TRI. Within the U.S., the state of Massachusetts has its own even more comprehensive program called the Toxics Use Reduction Act (TURA) that requires reporting of 1400 toxic chemicals. Annual emissions reports must also detail how the chemicals are used and how their use may be reduced within the entire life cycle, with two-year and five-year reduction goals. Between 1990 and 2000, firms in Massachusetts reduced the use of toxic chemicals by 45% and releases into the environment by 92% (Koch & Ashford 2005).

The first inspiration to create an EU emissions inventory for use by the public came from the Rio Declaration in 1992. Later, in 1996 the Directive concerning Integrated Pollution Prevention and Control (IPPC) put the idea into concrete terms, and what is now known as the European Pollutant Release and Transfer Register (E-PRTR) finally began with the adoption of the Commission Decision on the European Pollutant Emission Register (EPER) in 2000. This was adopted specifically to address the United Nations Economic Commission for Europe's (UNECE) Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, commonly known as the Aarhus Convention which entered into force in 1998. In 2003 the Parties adopted the Protocol on Pollutant Release and Transfer Registers (PRTR), which entered into force in October 2009. In compliance with this protocol, the E-PRTR was established under Regulation (EC) No 166/2006 (EEA 2011).

The E-PRTR contains data on releases of pollution to air, water, and land from approximately 24,000 industrial facilities that can be categorized into 65 economic activities within the following nine industrial sectors[2]:

1. Energy
2. Production and processing of metals
3. Mineral industry
4. Chemical industry
5. Waste and waste water management
6. Paper and wood production and processing
7. Intensive livestock production and aquaculture
8. Animal and vegetable products from the food and beverage sector, and
9. Other activities

[2] Forty-four out of the 65 economic activities included facilities that reported toxic releases of at least one of the pollutants included in this study. The list of the 44 economic activities included can be found in Appendix 2: List of all sub-sectors that reported toxic releases to the E-PRTR in 2008 and total number of facilities per sub-sector. A full list of the economic activities and pollutants regulated under the E-PRTR can be found at the E-PRTR website: http://prtr.ec.europa.eu

The facilities are located across the 27 EU Member States as well as members of the EFTA which includes Norway, Iceland, Switzerland, and Liechtenstein. Data is currently available from the first three reporting years: 2007, 2008 and 2009. The data consists of total annual emission releases during normal operations and any accidents that occur. Not every industrial facility in the EU is required to report its emissions. A facility must report its emissions data to the E-PRTR if the following criteria are fulfilled: (a) the facility is categorized under one of the 65 economic activities, (b) at least one of the E-PRTR capacity thresholds is exceeded, and (c) the facility releases pollutants or transfers waste off-site in levels exceeding the thresholds set in Article 5 of the E-PRTR Regulation (see the E-PRTR website for more information on the thresholds). The thresholds were set with the intention that about 90 percent of the total mass emissions from facilities for each pollutant covered would be regulated by E-PRTR (EEA 2011). A total of 91 pollutants are required to be reported on within the following seven groups:

1. Greenhouse gases
2. Other gases
3. Heavy metals
4. Pesticides
5. Chlorinated organic substances
6. Other organic substances
7. Inorganic substances

Both the TRI and the E-PRTR rely on the accuracy and honesty of the reporting companies as the sheer amount of data makes it impossible to conduct compliance checks. The data reported to the E-PRTR can be based on calculations, estimations, or measurements of emissions. Although it is the responsibility of national authorities within the Member States to assure the completeness and accuracy of the facility reports, the EEA does carry out analyses in order to search for anomalies within the data, with a higher level of attention and scrutiny given to selected pollutants. One caveat of emissions registers like the TRI and the E-PRTR is that they do not identify whether or not the reporting firms are in compliance with environmental regulations. Although it would be ideal to know if some of the outlying firms are indeed in violation of emissions regulations, for the purpose of this analysis it is assumed that all firms are operating in compliance.

The thresholds for reporting vary widely by pollutant. For example, the threshold for emissions of polychlorinated biphenyls (PCBs) is zero kg per year when released to air and soil and one kg per year when released to water, effectively requiring any emissions whatsoever to be reported. In contrast, releases of tetrachloroethylane to the air must only be reported by a facility when they reach above 2,000 kg per year. Therefore the E-PRTR does not provide the entire picture of every kilogram of toxin released, but rather an idea of the total facilities that each produce a considerable amount of pollution.

It should be noted that no one claims that the data contained within the TRI nor the E-PRTR is near 100 percent accurate, nor is it a complete account of all pollution required to be reported under the legislation. About 3% of the facilities reporting to the TRI are audited in any given year. The E-PRTR states that some reported data may not be uploaded into the database due to “technical issues related to data format, confidentiality claims or delay in data collection, validation and compilation”. Furthermore it declares that “some reported data might contain errors that significantly affect the EU and country totals” (European Topic Centre Air and Climate Change [ETC/ACC] 2010). If anything it appears that such errors lead to underreporting of emissions since annexes were issued in 2010 to complete information reported by 931 facilities in Italy from the 2008 reporting year, for example. It is unclear if the online database was updated with the figures, or if they may only be found in the annexes issued. Therefore the data continues to be modified and completed even after three reporting years have passed, meaning that attempts to replicate this research may have slightly different results [the data for this study was downloaded in March 2011]. As the E-PRTR has only just released data from the third reporting year, these issues may be resolved in the years to come. Keeping this in mind, the following results should be viewed more as trends and indicators of the overall direction of disproportionality in toxic emissions as opposed to fixed or concrete values.

3.2 Aim

The original aim of this study was to mimic Freudenburg's methodology as closely as possible in order to obtain statistics regarding disproportionality in the EU that could be directly compared to his statistics for U.S. industries. Upon becoming more and more familiar with the E-PRTR, it became clear that this emissions register is simply not comparable enough to the TRI used by Freudenburg, in neither its structure nor its contents, and thus obtaining comparable statistics would be difficult at best.

The major differences between the E-PRTR and the TRI are outlined as follows. First, as its name implies, the TRI requires data to be reported only on the emission of toxic chemicals of which there are 593 named by the EPA whose emissions must be reported. The E-PRTR on the other hand mandates reporting for only 91 pollutants, not all of which are classified as toxic. Indeed as explained above, the E-PRTR includes seven different categories of pollutants. When analyzing the data from the E-PRTR in this study, only those pollutants in common with the TRI were included in the analysis, which came out to a total of 48 toxic pollutants (see Appendix 1: Toxic pollutants tested for in this study for the list of pollutants included). Thus the results of this study will show the disproportionality in toxic emissions to the greatest extent allowed by publicly available data in the EU; however with data available for only 48 toxins instead of 593, the results will not provide the full picture of disproportionality. See Saarinen (2003) for recommendations that would improve the comparability of national emissions registers in order to avoid such problems in further studies.

Freudenburg was in some cases able to control for production output and employment levels not only on an industry-wide scale, but also for individual facilities. Although this information is sometimes possible to find for EU industries and facilities by performing individual searches, there is no single source like the U.S. Census Bureau that Freudenburg used to obtain such data. This is one disadvantage of conducting this study for the entire EU, rather than on a national level, and a major reason why the full range of Freudenburg's work could not be replicated in this case.

As this analysis includes data from 31 countries, it is too broad to be able to probe into the details and draw reliable conclusions about how and why the results are this way; there are simply too many confounding factors at the EU-wide level, some of which are discussed in the sections that follow. This study sets a framework for using the E-PRTR to analyze disproportionality and provides recommendations for further possibilities to conduct national level studies in the EU.

3.3 Methodology

Given the challenges described above, it was determined that the most appropriate way to proceed would be to extract a few select statistics from the Freudenburg study where the availability and organization of E-PRTR data would allow for comparable results. Though the few resulting statistics will not provide a robust analysis of the level of disproportionality in the EU, they will serve as an important first step towards broadening this research into the EU, and will give a glimpse of the trends in disproportionality in comparison with U.S. levels. Therefore the following statistics from Freudenburg 2005 were chosen in order to replicate with EU data from the E-PRTR:

1. "Roughly 60% of all toxic emissions in the US could be traced to just two industrial sectors – chemicals and primary metals – that jointly account for less than 5% of GNP. They involve just 1.4% of jobs, leading to disproportionality of 20:1"

   Objective 1: Find the proportion of toxic emissions from the chemicals and primary metals sectors in the EU compared to the EU total. Compare it to employment and GNP data if possible.

2. "In 1993, two companies (DuPont and Freeport-McMoRan) reported 1/3 of all toxic releases from the entire chemicals sector, more than 14% of released in the entire database. These companies have 0.06% of US GNP and 0.09% of US employees."

   Objective 2: Find the top polluting companies from the chemicals sector. Calculate the entire amount of emissions from the chemicals sector and the entire database to find emissions percentages for the top companies.

3. "80% of total risk within the most polluting sector, metals, is associated with Primary Non-Ferrous metals"

   Objective 3: Calculate the percentage of emissions from the primary non-ferrous metals category within the entire metals sector.

4. Freudenburg found a Gini coefficient for the distribution of toxic releases (in pounds) of 0.755.

   Objective 4: Calculate the gini coefficient for the entire EU database.

The first step was to determine which pollutants would be included in the analysis. As explained above, the study was limited to including toxic pollutants regulated by the TRI that are included in the E-PRTR, for a total of 48. The datasets were then downloaded for each of the 48 pollutants from 2008 for all reporting states to the E-PRTR, which is a total of 31 (data from 2008 was the most recent available data at the start of this study, although the data from the 2009 reporting year is now available). The 48 datasets were combined to make one database consisting of all reported toxic pollution emissions to air, land, and soil in 2008. The total toxic pollution emissions were then calculated for each unique facility from the 21,429 reports of different pollutant releases. A total of 9,976 individual facilities from nine sectors and 45 subsectors resulted. Appendix 2: List of all sub-sectors that reported toxic releases to the E-PRTR in 2008 and total number of facilities per sub-sector lists the subsectors and the distribution of total number of facilities by subsector. Accidental pollution discharges were omitted from the calculations in order to understand the trends in disproportionality under normal circumstances.

Although it would be interesting to consider conducting this study to test for toxic pollution on the company level instead of the facility level, the data organization does not allow for this.

However, Freudenburg's study was based on individual facilities and thus it is relevant to conduct this study in the same way.

3.4 Results

The overall results of this limited analysis are more or less comparable to those found by Freudenburg in U.S. industries: an alarming degree of disproportionality in releases of toxic pollutants also exists within industries in the EU. Table 3-1 summarizes the key findings for the EU compared to the U.S.

Table 3-1. A comparison of the statistical analyses of disproportionality in toxic pollution emissions across and within sectors in the U.S. and the EU. Source of U.S. data is Freudenburg (2005).

	Disproportionality in the U.S.	**Disproportionality in the EU**
Objective 1: Most disproportionate sectors	60% of toxic emissions are from two sectors: chemicals and primary metals	60% of toxic emissions also come from two sectors: chemicals and minerals
Objective 2: The proportion of pollution from the top two chemicals facilities	Two companies released 33% of all toxic emissions from the entire chemicals sector, more than 14% of released in the entire database	Two companies released 32% of all toxic emissions from the entire chemicals sector, approximately 13% of emissions released in the entire database
Objective 3: Most disproportionate subsector	Primary non-ferrous metals accounts for 80% of emissions within the most disproportionate sector, metals	Production of basic organic chemicals accounts for 70% of emissions within the most disproportionate sector, chemicals
Objective 4: Gini coefficient	0.755	0.983

3.4.1 Objective 1

Freudenburg found that 60% of all toxic emissions in the U.S. were from just two sectors: chemicals (45.79%) and primary metals (13.38%). In the EU, the chemicals and metals industries together comprised 41.83% of all toxic emissions, as seen in Figure 3-1. However in this case although the chemicals industry, which makes up 17.5% of all facilities released 40.9% of all toxic emissions, the metals industry released just 0.93% of all toxic emissions. In the EU, the mineral and the waste and wastewater treatment industries each make up approximately 20% of emissions. The mineral industry consists of just 5.89% of facilities, while the waste and wastewater treatment industry makes up 15.38% of all facilities, making its emissions much more proportional.

Although the chemicals industry released 45.79% of all toxic pollution in the U.S., it contributed to just 2.92% of the U.S. GDP. In the EU, the chemicals industry contributed to just 1.1% of the EU's total GDP and 6.25% of the total GDP of all industry in the EU, as seen in Figure 3-2 and Figure 3-3. The entire chemicals industry in the EU employs 1.9 million people, which although not an insignificant amount, is just a minute fraction of the total workforce (Eurostat 2010). The industry accounts for one-third of all industrial energy usage in the EU, despite the fact that it contributes just 6% of industrial GDP (Eurostat 2010).

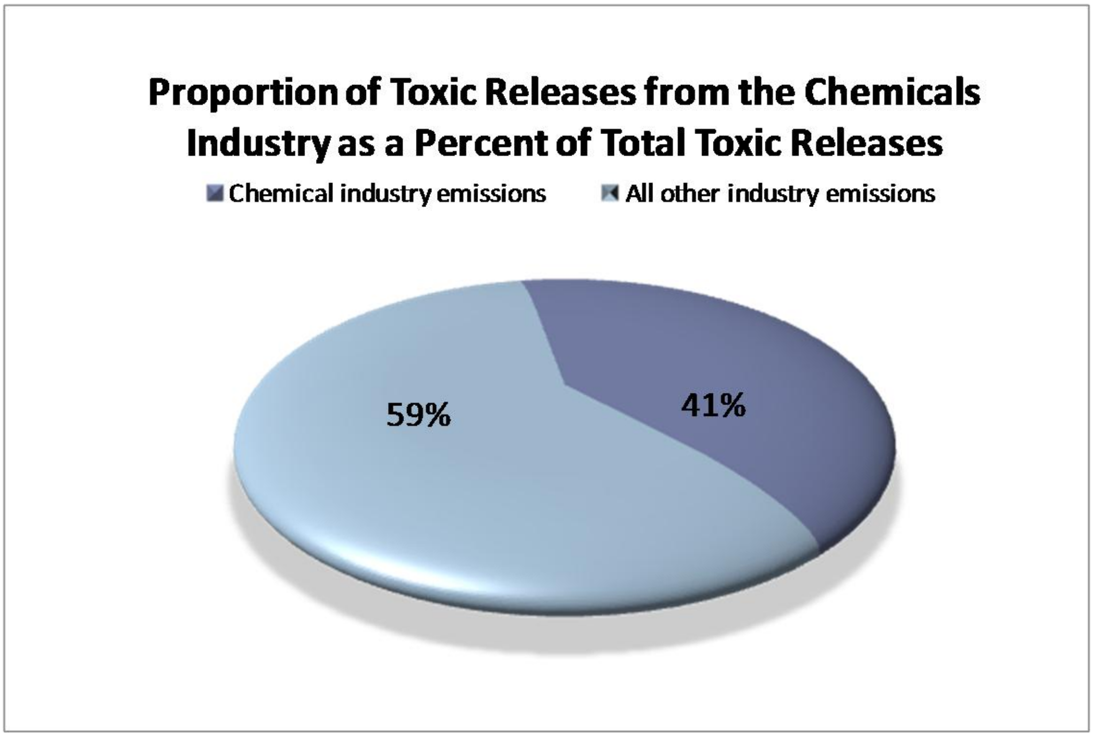

Figure 3-1. Proportion of toxic releases from the EU chemicals industry as a percent of total toxic releases.

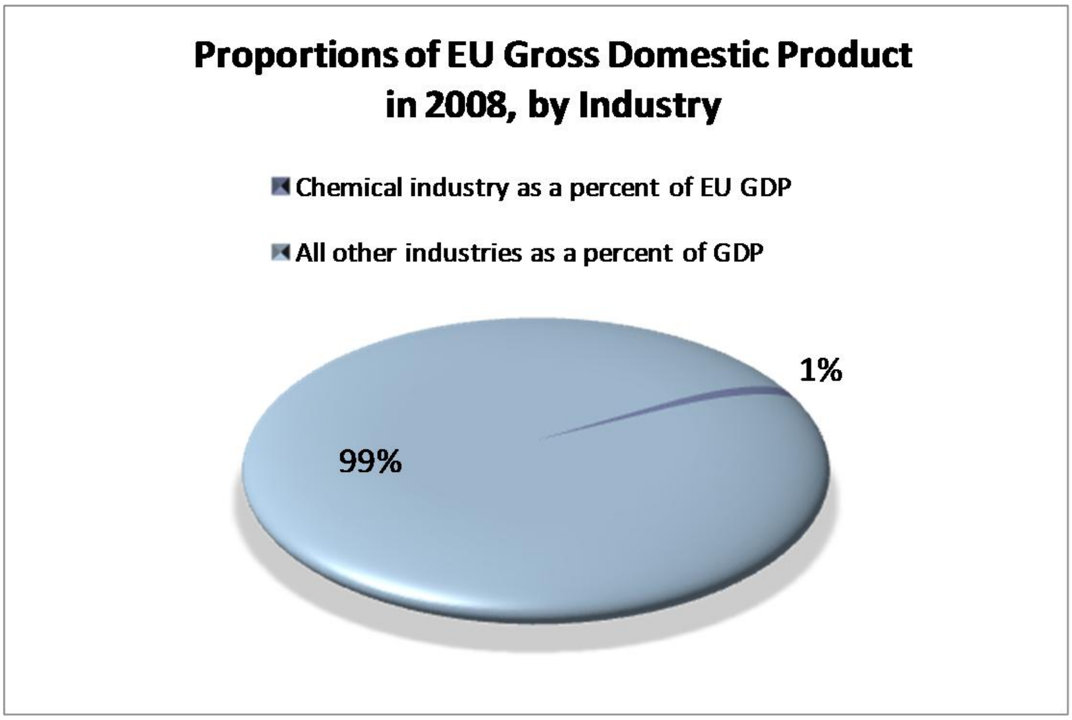

Figure 3-2. Contribution of all EU chemical firms to total EU GDP in 2008.

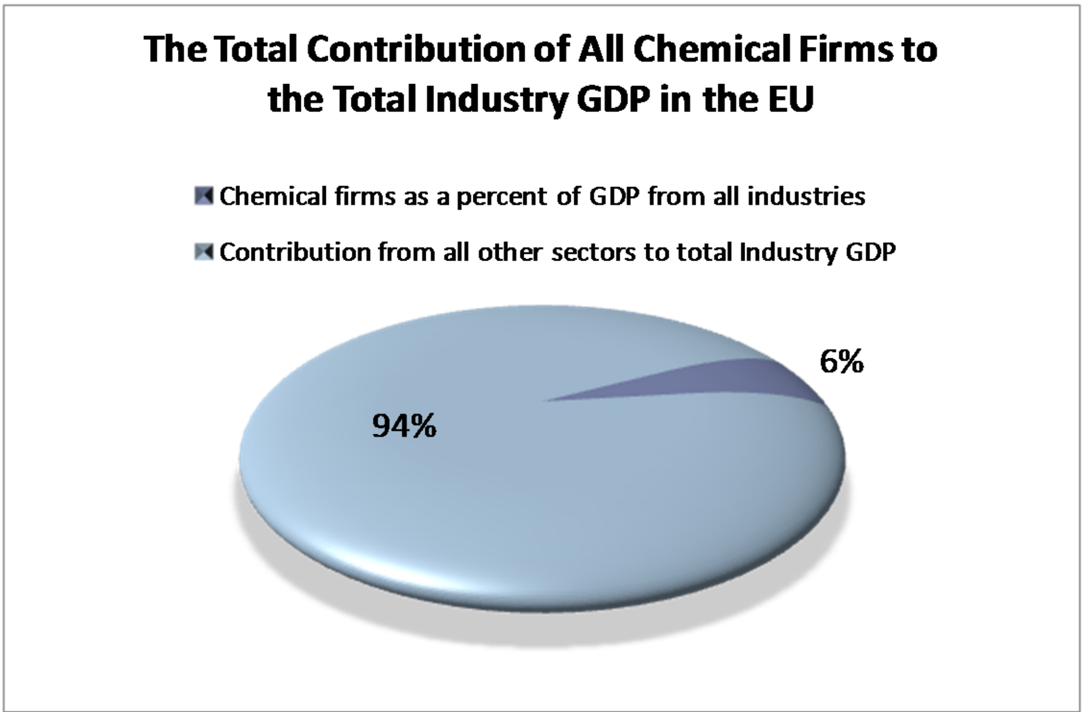

Figure 3-3. Contribution of all EU chemical firms (not only those included in this study) to total industry GDP in the EU.

Figure 3-4 shows the percentage of total toxic pollution emitted by eight EU countries within the chemicals industry compared to the percent of total EU chemicals sales from those countries in 2008 (see Appendix 3: Proportion of selected countries' toxic emissions from the chemical sector versus proportion of total chemical sales (2008 data)for the exact percentages).

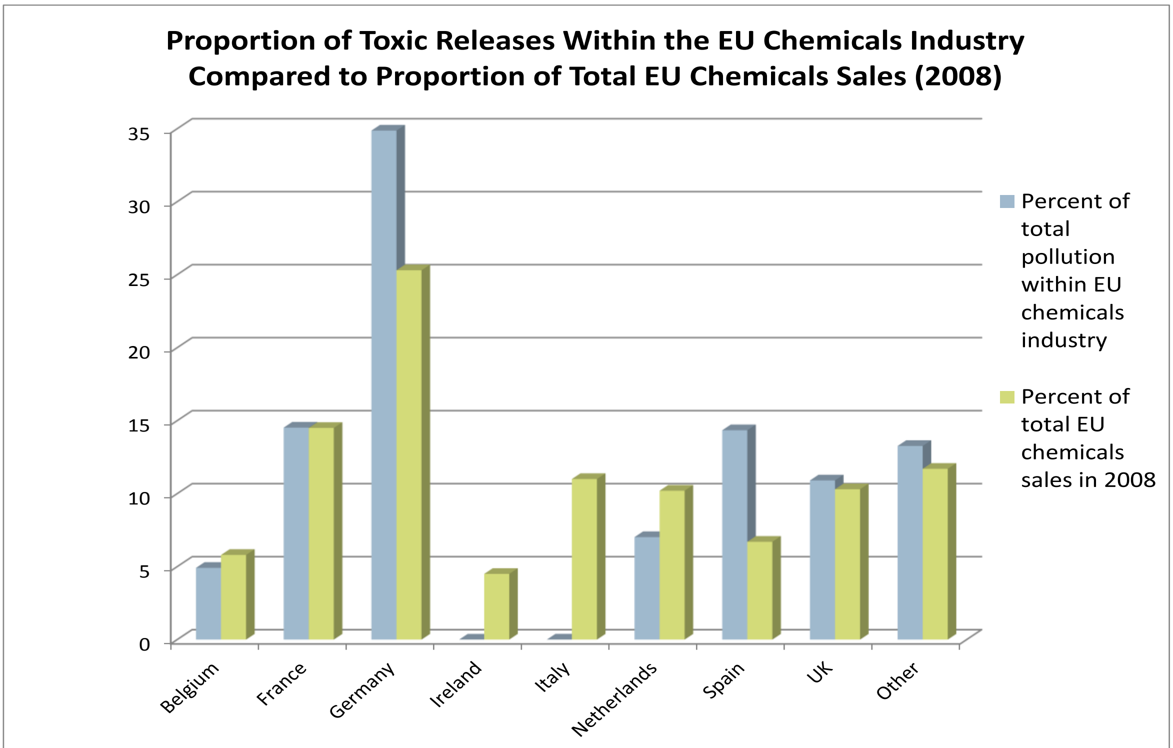

Figure 3-4. Proportion of toxic releases from the EU chemicals industry compared to proportion of total chemical sales. Chemical sales data is from KPMG International (2010).

In 2008 several of the top ten global chemical producers in terms of sales value were based in the EU. The number one company, BASF, is based in Germany. Twelve different BASF facilities located throughout the EU reported releases of toxic emissions in 2008. Although it was the highest grossing chemical producer in the world, toxic pollution emissions from BASF made up only 0.3% of all toxic pollution emissions in the EU and 0.77% of all toxic pollution emissions within the chemical industry in 2008. Similarly, the fifth largest chemicals producer in 2008 was a UK company called INEOS. A total of 21 INEOS facilities reported toxic emissions, totaling 0.04% of all chemical industry releases and 0.02% of all toxic releases from the database. Although further investigation is needed to draw conclusions in this case, this data suggests that true to Freudenburg's findings, the facilities producing the greatest levels of pollution within a given industry are not the ones contributing the most towards GDP or employment.

3.4.2 Objective 2

Freudenburg reported that two companies (DuPont and Freeport-McMoRan) released one-third of all toxic emissions from the entire chemicals sector, more than 14% of emissions released in the entire database. Together these companies made up 0.06% of U.S. GNP and 0.09% of the U.S. workforce. Interestingly enough, DuPont was the world's ninth largest chemical producer in 2008, behind BASF and INEOS mentioned above. Yet while DuPont released around 7% of all toxic releases in the U.S., BASF and INEOS combined released only 0.32% of all toxic emissions in the EU.

The top two polluting companies in the EU chemicals industry (out of 1690) are DOW Deutschland Anlagengesellschaft Werk Stade mbH, located in Germany, and Solvay Quimica in Spain. DOW released 19.09% of all emissions within the chemical industry and 7.81% of total emissions, while Solvay Quimica released 12.61% of all emissions within the chemical industry and 5.16% of total emissions. Together, this amounts to 31.7% of chemical industry emissions and 12.97% of total emissions, very comparable to the levels of disproportionality displayed by the top two chemical companies in the U.S. Furthermore, although the organization of the data does not allow testing for pollution by company, four out of the top ten highest polluting chemical facilities belong to Solvay Quimica. BASF and INEOS, the number one and number five highest grossing global chemical companies in 2008, do not have any facilities in the list of the top ten highest polluting chemical industry facilities.

3.4.3 Objective 3

Freudenburg found that the sector with the highest proportion of pollution was the metals sector. And within this sector, 80% of disproportionality within this single sector was attributed to one subsector, primary non-ferrous metals. Within the EU metals sector, non-ferrous metals production accounts for just 10% of emissions within the metals sector.

The highest polluting sector in the EU is the chemicals sector, with 41% of total toxic emissions and just 17.5% of total facilities. Within this sector, subsector 4b, "Industrial scale production of basic inorganic chemicals" accounts for 70% of emissions and 29% of emissions from the entire database, out of 45 distinct subsectors. The average amount of reported toxic emissions per facility in subsector 4b is 12,792,132 kg while the median is just 312.5 kg.

This data shows that there are layers to disproportionality. If you look beyond the sector with the highest pollution and probe within the further subsectors it may be possible that focusing funds for regulation or innovation towards just one specific subsector could have significant implications for pollution reduction. In this case, subsector 4b includes just 151 out of the total 9,976 facilities.

3.4.4 Objective 4

In order to demonstrate more explicitly the high level of inequality in pollution emissions within sectors, Freudenburg calculated a Gini coefficient to show the proportion of industrial sectors plotted against the proportion of toxic releases. The result was a Gini coefficient of 0.755, higher than any Gini coefficient ever recorded for even the most unequal society. Figure 3-5 displays the Lorenz curve, a visual representation of the Gini coefficient for the distribution of toxic emissions across all facilities in the U.S.

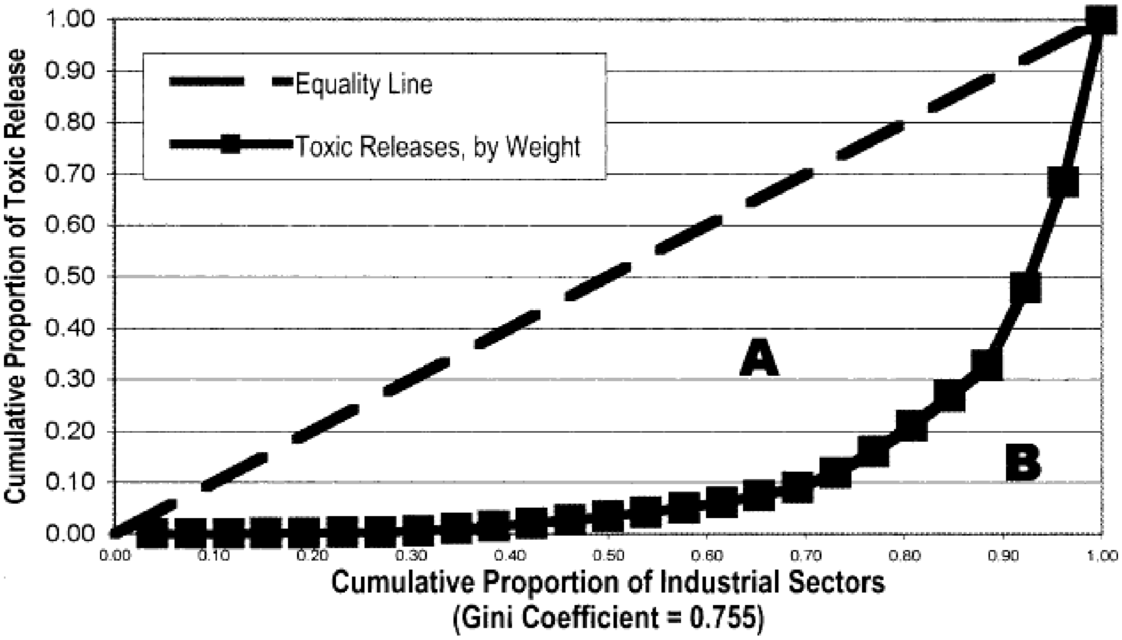

Figure 3-5. Proportions of toxic releases from industrial sectors in the U.S. Source: Freudenburg 2005.

The Gini coefficient calculated for this study using the emissions from all 9,976 facilities is 0.983 – this is an amazingly high figure which indicates that just a handful of facilities are responsible for almost 100% of the total pollution. As seen in Figure 3-6, the toxic emissions from 90% of the facilities are negligible in comparison to the emissions from the top 10% of facilities. When the top 100 (1.0%) facilities are removed, the Gini coefficient for the remaining 8,976 facilities drops from 0.983 down to 0.9; when considered in the overall context this is not a considerable drop, however when considering that just 1.0% of the facilities were removed, the impact of that 1.0% becomes more apparent. With the top 1000 (10%) facilities removed the Gini coefficient falls drastically to the much more moderate level of 0.57. While 0.57 is not an ideal distribution, it is significantly more favorable than 0.983. Figure 3-7 displays the Lorenz curves for these calculations.

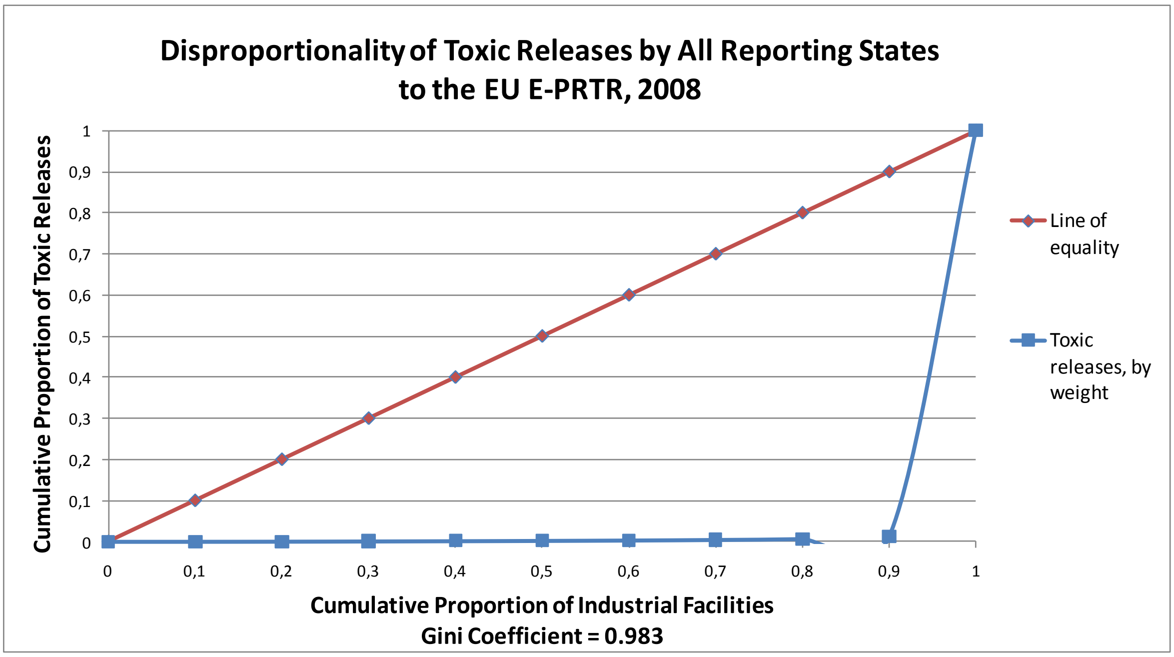

Figure 3-6. Proportion of toxic releases across industrial sectors in the EU. Data source: E-PRTR.

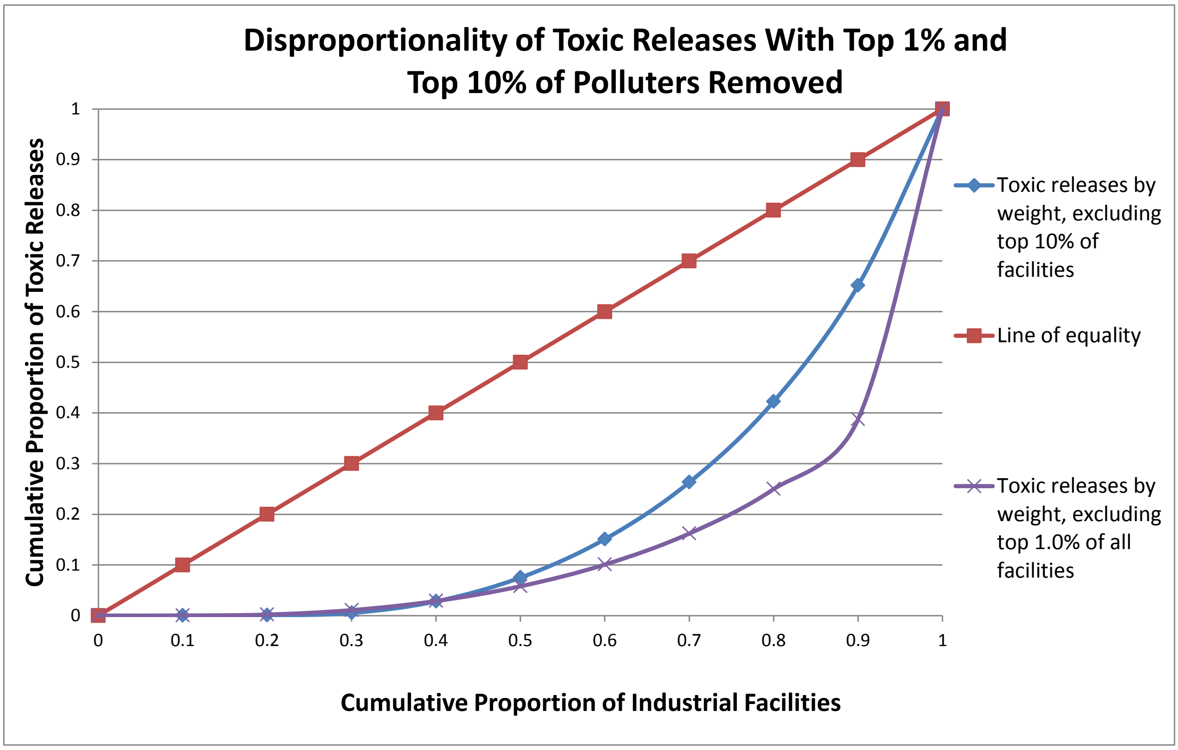

Figure 3-7. Proportion of toxic releases across all industrial sectors in the EU with the top 1.0% and the top 10% of all polluting facilities removed. Data source: E-PRTR.

As this Gini coefficient is extreme by all accounts, further tests were done to explore how and why it is possible for this coefficient to be correct. The first thing to note is that the facility with the smallest amount of toxic pollution reported releasing just 200 grams. In fact 802 facilities, or nearly 10% of all facilities, reported releases of just 100 kg or less. At the other end of the scale the disparities are more dramatic. The 100th greatest polluter released 17.3 million kg of pollutants, while the top facility released 2.8 billion kg.

Unfortunately due to the organization of the E-PRTR it is possible that a portion of the pollution reported by some of the highest polluting facilities is not in fact toxic pollution. Since the U.S. TRI is devoted solely to toxic substances, there is no question about the nature of the pollutants' toxicity. The E-PRTR on the other hand contains seven different categories of pollutants, not all of which are toxic. The pollutants emitted in the greatest amounts by weight were classified as "chlorides (as total Cl)" and "total nitrogen". Chlorides and nitrogen are in fact naturally occurring substances that are only toxic in certain states and compounds. Unfortunately while the TRI identifies specific toxic releases such as trichloracetyl chloride, triphenyltin chloride, and dimethylcarbamyl chloride among others to be reported, the E-PRTR groups all substances containing chloride together, so it is impossible to know specifically which substance has been emitted.

Therefore in order to examine whether or not certain substances being emitted in massive quantities were skewing the distribution enough to render the Gini coefficient unreliable, the data was filtered to include only those facilities that released heavy metals. All eight heavy metals in the E-PRTR are known to be toxic in various forms, have comparable reporting thresholds set by the E-PRTR, and none should be emitted in many millions or billions of kilograms by a single facility (as is the case for chlorides), thus the coefficient for heavy metals could be expected to be more equal. The Gini coefficient for all 3,087 facilities emitting heavy metals is 0.91. Within this group, 0.1% of all facilities emit 72% of all heavy metal emissions. The top 10% of facilities emit 87% of emissions.

The next step is to perform a similar test within a selected industrial sector, as the other coefficients have been calculated across sectors. Thus the Gini coefficient was calculated for subsector 4b, industrial scale production of inorganic chemicals, which is the most disproportionate emitter of toxic pollutants when measured against other sectors. The Gini coefficient within this subsector is 0.92. The Gini coefficient for the entire chemicals sector is 0.97. Since it had been established that the chemicals sector is the most disproportional, Gini coefficients for several other randomly selected subsectors were chosen in order to investigate the levels of disproportionality at the deepest level possible. The lowest coefficient calculated for an entire subsector was 0.65, for subsector 7a, intensive rearing of poultry and pigs. The rest of the coefficients calculated for random subsectors remained around 0.92. Appendix 4: Gini coefficients within and across selected sectors displays the results for all Gini coefficient calculations that were done.

The sheer number of different pollutants in the TRI as compared to the E-PRTR is another reason why the Gini coefficient for the E-PRTR may be so extreme. Even though the Gini coefficient calculated by Freudenburg is also considered to be quite extreme, it included emissions data from over 12 times as many pollutants as this study, which provided a broader range of different figures. It is unclear how many individual facilities were used in the calculations for his study.

There is a possibility that if Freudenburg's study using U.S. TRI data were replicated today, the Gini coefficient may rise to be closer to the EU value. This is because Freudenburg's study was conducted using data from the 1993 reporting year, and since this time the reporting thresholds have decreased at least once. For example, in 2002 the threshold for reporting lead releases was lowered from 25,000 pounds (11,339 kg) per facility per year down to just 100 pounds (45.35 kg). Although this undoubtedly increased the total number of facilities required to report emissions, it also drastically increases the range of inequality which would result in a higher Gini coefficient if other circumstances remained unchanged. The E-PRTR's threshold for lead emissions is 100 kg per year when released to air and 20 kg per year when released to soil or water.

Two main criticisms of using the Gini coefficient as a measure of disproportionality may arise in this case. Based on the information above regarding the wide range of emissions reported from 200 grams all the way up to 2.8 billion kg, it would seem to make sense to hypothesize that recalculating the emissions from weight into a toxicity factor would provide a more truthful view of the actual risk posed by the highest polluters. However when Freudenburg did exactly this, the Gini coefficient unexpectedly rose by a full 0.11 points up to 0.865. Still, given the uncertainties regarding the toxic nature of some pollutants due to aggregated reporting (i.e. total chlorides), it may be worthwhile to do this in any future studies of the double diversion using the E-PRTR. The second criticism that may arise is once again the fact that the Gini coefficient does not take into account any factors to control for the size, output, or employment level of the facilities in question. This is a fair criticism given that the database contains everything from family-run operations to facilities run by multi-national corporations. Again, although it was not possible to impose controls for these factors in this study, Freudenburg was able to do so with the surprising result of *increased* Gini coefficients. The coefficient rose when controls were imposed for the size of the payroll, and rose again even further with controls for employment levels, as displayed above.

3.4.5 Overall Trends

Despite the emphasis this report has placed on analyzing pollution data within industrial sectors, it is worth noting the overall trends between all sectors and facilities. It must be emphasized that an individual facility's level of emissions is not necessarily correlated with its environmental performance; this cannot be determined without controlling for other factors related to the facility's production. Still, even when lacking the data that would allow for the most robust assessment of these facility's environmental performance, some valuable observations can be made that may serve as the foundation for future research.

The obvious outlier from the entire dataset is C.D.E. Eivissa, a thermal power station located in the town of Eivissa on the Spanish island of Ibiza in the Mediterranean Sea. This single facility released 2.8 billion kilograms (2.8 million tonnes) of toxic pollution in 2008. As just one facility out of 9,976 individual facilities that released toxic pollution in the EU in 2008, representing 0.01% of such facilities, C.D.E. Eivissa released 13.45% of all toxic pollution in the EU that year. This demonstrates a greater level of disproportionality than Freudenburg found in the U.S., where two companies, DuPont and Freeport-McMoRan, were responsible for 14% of all toxic emissions (Freudenburg 2005).

One argument that has been brought up in cases of such extreme statistics is that perhaps the firm is providing a necessary product that simply requires such high levels of pollution. In order to check the validation of this argument in this particular case, C.D.E Eivissa's emissions were then analyzed within the most narrow context possible in order to compare the emissions to those of other facilities in subsector 1c, "thermal power stations and other combustion installations". In total 560 individual facilities in subsector 1c reported toxic emissions to the E-PRTR in 2008. C.D.E Eivissa emitted 79% of all toxic emissions from all thermal power stations in the EU. The most robust measure of the disproportionality would be provided by an analysis of the amount of power produced by the facility in comparison to the others which produced less emissions.

Although internet accounts varied on the exact amount of energy produced by C.D.E. Eivissa in 2008, it is known that the plant supplies energy to the entire island of Ibiza, which had a population of about 130,000 people in 2009 (excluding tourists) (Instituto Nacional de Estadística 2009). Without doing the math, it is obvious that the amount of pollution emitted by C.D.E Eivissa is hugely disproportionate when considering that it supplied energy to just 130,000 people. For the purpose of comparison a facility from the same subsector was chosen at random. Seabank Power Ltd. is ranked number 130 out of 560 facilities in subsector 1c for its emissions, with C.D.E. Eivissa being number one. Seabank Power Ltd. emitted 0.002% as much pollution as C.D.E. Eivissa while producing energy for 1.6 million people, or 12.3 times as many people. Although this facility was chosen at random, while searching for its annual output it was found that it employs an environmental consulting firm to certify its employees in waste reduction and management.

In fact when C.D.E. Eivissa's emissions are combined with those of the second highest polluting facility in the database, DOW Deutschland Anlagengesellschaft Werk Stade mbH, a manufacturer of organic basic chemicals in Stade, Germany, the combined emissions of the top two facilities is 21.26% of the total toxic pollution emissions from 9,976 facilities. The top five facilities, comprising 0.05% of all facilities, produced 35.1% of all toxic emissions. The top ten facilities, comprising 0.1% of all facilities, produced 47.74% of all toxic emissions in the EU in 2008. The average amount of toxic pollution emitted by all firms was 2.08 million kg, meaning that C.D.E. Eivissa's toxic releases in 2008 were 1,341 times the average amount in the EU. When the top 10 highest polluters are emitted from the calculation for the average, the average for the rest of the 9,966 firms drops to almost half the original average: 1.08 million kg instead of 2.08 million kg. Using this average, C.D.E. Eivissa's emissions are 2,564 times the average. The median amount of pollution emissions is 16,900 kg, making C.D.E. Eivissa's emissions 165,088 times the median.

The top 10 greatest polluters in the database include facilities from three out of the nine sector categories in E-PRTR and four activities as follows:

1. Energy Sector:

    (1c) Thermal power stations and other combustion installations (one facility)

3. Mineral industry

    (3a) Underground mining and related operations (two facilities)

4. Chemical industry

    (4a) Industrial scale production of basic organic chemicals (one facility)
    (4b) Industrial scale production of basic inorganic chemicals (five facilities)

The geographical distribution of the top 10 facilities is as follows: Germany (5), Spain (1), France (1), Poland (1), and the United Kingdom (1). The five facilities in Germany together released 20.8% of all toxic emissions from the database in 2008.

Finding employment and production data to put the statistics into context proved difficult to do on an EU-wide basis, compared to the U.S. which has readily available national databases. Although Eurostat provides comprehensive aggregated data on such indicators for individual NACE sectors (European classifications for industries), it is based on data from the entire sector. Therefore those figures cannot accurately be applied as controls for E-PRTR data because only those facilities that meet the thresholds for pollution emissions set in the E-PRTR legislation are included in the emissions data. For example Eurostat reports that there are 33,600 chemical companies operating in the EU-27, but just 1690 with public emissions data met the criteria to be included in this report. It is unclear how Freudenburg accounted for such discrepancies in his calculations.

A typical reaction upon seeing some of the disproportional figures above may be that the highest polluters are simply outliers, which are bound to exist within large groups of data. In part, this is true, however it is important to assess the significance of the outliers and the effect that they have on the overall industry's environmental performance. Average figures for emissions across one or several industries are distorted when the outliers are taken into account. Table 3-2 shows the differences in averages calculated for toxic emissions from the entire database, and what happens to the average when the top polluting facilities are removed. Removing the top 10 highest polluting facilities out of 9,976 total facilities and calculating a new average using emissions data from the remaining 9,966 facilities results in a 48% decrease in the emissions average, from about 2.08 million kg to about 1.08 million kg.

Table 3-2. Average emissions (kg) from the entire dataset, showing the difference in averages when top polluters are removed.

Average kg per facility	2.08 million kg
Average kg per facility w/o #1	1.8 million kg
Average kg per facility w/o #1-5	1.35 million kg
Average kg per facility w/o #1-10	1.08 million kg
Average kg per facility w/o #1-25	677,000 kg
Average kg per facility w/o #1-50	445,500 kg
Average kg per facility w/o #1-100	294,500 kg

3.5 Discussion

Recalculating the emissions reported in kilograms into a weighting based on their toxicity as Freudenburg did was beyond the scope of this study. Nevertheless it should be noted that weighting the emissions by toxicity may have an effect on the results of this study. For example in that case, C.D.E. Eivissa may no longer be the top polluter since the toxicity of the main pollutant it emitted, chlorides, is lower than some other toxics; thus, the vast amounts of chlorides released (2,790,001,084 kg in the case of C.D.E Eivissa) may result in the same toxicity risk posed by another facility's emissions of "only" 1,500,000 kg of a different pollutant, for example. In fact, a quick analysis of the data revealed that many of the top polluters reported releasing large amounts of chlorides. Therefore as a quick experiment, chlorides were removed from the database to see if any major changes in the results were evident. Indeed, the top 10 polluters are completely different. In order to check if the massive quantities of chlorides clustered at the top of the database had skewed the Gini coefficient calculation, it was recalculated with all emissions of chlorides removed. In this case the coefficient falls to 0.833 – still very high, but not as extreme as the original coefficient. The point of this discussion is not to say that any particular toxic pollutants should be omitted from the analysis, but rather that weighting them by level of toxicity may simply produce different results. Those results may be of greater interest to policymakers when seeking the most efficient way to reduce impacts on human health and the environment.

In terms of looking at disproportionality specifically within releases of toxic emissions, this study is as comprehensive as possible given the level of reporting required by the E-PRTR. However, as noted above only 48 toxic pollutants were included in the criteria for the EU industries, while Freudenburg's analysis of U.S. industries included a total of 593 toxic pollutants as reported to the TRI. This is one reason why the results of this study are not completely comparable to Freudenburg's results. At this time, it is simply not possible to conduct an analysis of industrial toxic emissions in the EU at the same depth that Freudenburg did. Still, the results of this study are valuable in that they provide the first glimpse into the levels of disproportionality within EU industries given the pollutants and pollutant thresholds that the EU has identified as necessary for reporting.

A particularly interesting result from the analyzed data can be seen in Figure 3-4 above, comparing the proportion of toxic releases in the chemical industry to the proportion of the total EU chemical sales in 2008. The chemical facilities in France, Belgium, the UK, and the sum of the facilities in the rest of the EU emitted amounts of toxic pollutants relatively proportionally to the amount of chemical sales. France in particular emitted 14.52% of all toxic pollution from the chemicals sector in the EU, and made up 14.5% of total chemical sales; the UK also had a ratio of about 1:1. In the rest of the countries' chemical sectors, two types of disproportionalities are taking place. Germany and Spain both released noticeably more pollution relative to their sales volumes, characterizing the double diversion in the traditional sense as defined by Freudenburg. In Freudenburg's analysis of the primary nonferrous metals sector, he found that if the highest 10% of polluting facilities reduced their emissions to sales ratio to the median level of the other facilities in the same sector, the result would be an 83.5% reduction in the total toxic emissions from the entire industry. If only the single highest polluting facility did the same, 58.2% of emissions would be avoided (Freudenburg 2005).

The most interesting thing to note in Figure 3-4 is the two countries whose proportions of sales are significantly higher than their proportions of toxic pollution emitted. Facilities in Ireland contributed 0.0002% of all toxic pollution but comprised 4.5% of total chemical sales in the EU, while facilities in Italy released 0.0012% of all toxic pollution and made up a full 11% of all chemical sales. There are several possible explanations for the gap in these numbers; however the disparities are so large that no one explanation by itself is enough to justify the gaps. The first possibility is underreporting of emissions by chemicals facilities in Italy and Ireland. Another possibility is that there are many more chemicals facilities in Ireland and Italy that operate on a smaller scale and thus do not meet the thresholds required to report emissions to the E-PRTR, but the sum of their output contributes to the sales figures. A third explanation could be that within the six different subsectors that make up the chemicals sector (see Appendix 2: List of all sub-sectors that reported toxic releases to the E-PRTR in 2008 and total number of facilities per sub-sectorfor all the subsectors), there are some subsectors that require the use of more toxic products in the manufacturing process than others. An analysis of the distribution of the subsectors within and between the different countries revealed no major differences that would account for this. Therefore, given the uncertainties an in-depth analysis of the chemical facilities in Italy and Ireland may produce interesting insights into how the chemicals sectors of those countries managed to reverse the notion of disproportionality. Comparing data on specific factors such as the ages of the facilities for example would provide valuable insights that cannot be gleaned from numbers in a pollution register.

Although the environmental protection measures of these facilities is the topic for a separate study, it is worth noting some information on the expenditure for environmental protection by the public and private sectors in the EU. According to Eurostat, in 2006 the public sector and industry spent similar amounts of money on environmental protection, equaling 0.47% and 0.44% of GDP respectively (Eurostat 2010). This equaled €116 and €109 per EU in habitant respectively. A brief examination of the websites of some of the top 10 polluting companies from the entire database revealed lengthy sustainability reports and declarations of their commitment to the environment. Therefore it can be said that incorporating the principles of sustainability is, at least to some extent, part of the management practice in these companies. Examining individual case studies that involve interviews with sustainability managers of the most disproportional companies would be a very interesting topic for future research.

From the EC's informal review of the 2008 E-PRTR data that was released in 2010, it seems that they are aware of some levels of disproportionality, but rather than ascribing to Freudenburg's theory of the double diversion, several other potential explanations were offered. As mentioned in Chapter 2, the first response offered in the review was that countries should reassess these cases in order to ensure that no errors were made in reporting. Next they reasoned that perhaps the reporting thresholds are too high, resulting in a small number of facilities that report large quantities of emissions. That is not such a practical argument in terms of this report, since the review's examples were of non-toxic air pollutants which have much higher thresholds than the toxins in this report. For example, the threshold for reporting CO_2 emissions to air is 100,000 kg per year, while many of the pollutants included in this report have thresholds closer to 100 or 200 kg per year. The next hypothesis to explain the disproportionality was that reporting for other countries (besides where the anomalous facilities are located) is incomplete, causing a handful of facilities to skew the distribution. While this is certainly possible, most of the groups used in calculations for this report included at least several hundred or several thousand facilities meaning that underreporting of data would not be likely to have a huge effect on the distribution.

Although the figures presented in the Results section cast industries in a harsh light, credit must be given where it is due. It has already been mentioned that between 1995 and 2006, EU industries increased greenhouse gas emissions by less than 1% while experiencing economic growth of 37% (Eurostat 2010). The chemicals industry, which is shown to be particularly disproportionate in this study, also managed to decrease its emissions substantially during the same period. Emissions of greenhouse gases, acidifying pollutants, and ozone forming substances decreased by 28%, 47%, and 47% respectively (no information is available regarding trends in toxic pollution) (Eurostat 2010). This is a major feat that no doubt required dramatic efforts on the part of the industries. This is consistent with Freudenburg's (2005) and Berry's (2008) conclusions about the nature of the double diversion; in their studies, the vast majority of firms within a given sector are producing emissions at levels well within reasonable limits. It is the few facilities on the far end of the distribution that account for the majority of the emissions, perpetuating the industry's reputation for being 'dirty'. Given the impressive emissions reductions that have already been achieved without taking the double diversion into account in policy measures, there is huge potential for further reductions to take place by simply focusing on the outliers.

An argument that will inevitably arise from some who view these results will be that the chemicals industry is a vital component of the EU economy. Indeed, in 2007 chemicals accounted for 16% of all exports from the EU-27 (Eurostat 2009). Disproportionality theory does not argue that disproportional industries should be somehow removed from the economy or even highly regulated. Instead, the most disproportional facilities should be closely examined. In the case of the 1690 chemicals facilities included in this report, the median for toxic releases was 405.5 kg, while the average was 5,021,291 kg. The barriers to making strides toward reducing the disparity between the average and the median are not as great as one might think. For example, let us recall the study of chemicals facilities cited by Porter (1995) that was described in Chapter 2. The study of 29 chemicals facilities revealed 181 opportunities for pollution prevention activities, of which only one resulted in additional costs to the firm and 68 increased resource productivity. Given this, along with the data in Appendix 3 which shows the sales to emissions ratios of various EU countries, it is evident that disproportionality does not have to exist on this scale. It is possible for chemicals to continue to be a vital part of the European economy without contributing such a disproportional amount of toxic emissions.

As data from the subsequent reporting years are gradually released, it will become easier to see the trends in pollution and disproportionality. For example in 2007, which was the first reporting year for E-PRTR and the only other year with data currently available, C.D.E. Eivissa did not report any emissions of chlorides which resulted in significantly lower emissions for this facility in 2007 compared to 2008. When data from the following years is released, it will be simple to check whether or not the pollution levels reported in 2008 some of the facilities and industries discussed in this report was anomalous compared to other years[3]. It will also be interesting to note the effects on the levels of reported emissions, compared to the dramatic fall in reported emissions to the TRI described in Chapter 4.

[3] The data from the 2009 reporting year was released in the weeks before this report was published. Although it was too late to carry out any in-depth analysis of the new data, C.D.E Eivissa's reported emissions were checked. The facility reported drastically decreased emissions in 2009, supporting the hypothesis that its emissions in 2008 may have been an anomaly. Due to the fact that it takes several days to download and organize a pollution database, no further trends could be noted.

4 Implications for Policymaking

It is interesting to begin the discussion on policy and legislation by recalling a remark made by Freudenburg that was quoted in Chapter 1. Upon hearing about the proposal for this research project, Freudenburg observed that the results would be particularly interesting given the fact that "at least quite a few folks would argue that the idea [of the double diversion] shouldn't work as well, since EU regulations are often more effective than those in the U.S." (W.R. Freudenburg, personal communication, November 2011). Considering this comment in connection with the results presented and discussed above, many questions now arise. Given that EU industries display comparable levels of disproportionality, does this mean that national legislation is not to blame for the double diversion in the U.S.? Do the EU and the U.S. share commonalities in their regulation of toxic pollution that allows this extreme level of disproportionality to occur?

4.1 Current state of EU toxics regulations

4.1.1 The IPPC Directive

Given the fact that no other national emissions registries have been analyzed in the same capacity as in this study and Freudenburg's, it is difficult to make conclusions about whether or not there is something unique to EU and U.S. legislation that enables such disproportionate levels of pollution. The EU is an especially complex case to analyze given that industries operate under both national and EU-wide legislation. For the purposes of this study, only EU legislation will be examined.

Government regulation of toxic pollution emissions in the EU exists in many forms including standard setting, creating pollution reduction markets, mandatory disclosure of information, and government imposed liability (Ashford & Caldart 2010). Methods of regulation have evolved over the last 40 years since they have been imposed as a result of new information and advances in science, technology, risk assessment, cost-benefit analyses, etc. While the U.S. was the leader in implementing environmental law during the early years of the modern environmental era, President Reagan ushered in an era of antiregulatory politics; since this time support for employing the precautionary principle in the U.S. has waned, while in the meantime it has been incorporated into EU legal directives (Ashford & Caldart 2010). Even when examining only EU law, emissions to air, land, and water have historically been regulated separately under different statutes such as the Water Framework Directive and the Directive on Air Quality and Management.

The Integrated Pollution Prevention and Control (IPPC) Directive (Directive 2008/1/EC) which entered into force in the EU in 1999 combines efforts to combat air, land, and water pollution into an integrated approach that focuses more on prevention that control. About 50,000 large industrial facilities are governed by the IPPC Directive. The overarching goal of the Directive is to minimize industrial pollution in the EU. It is based on four main principles. First, it encompasses an integrated approach meaning that all aspects of environmental performance from use of raw materials, to energy efficiency, to accident prevention, to site restoration upon closure. Second, when permits with emission limit values are issued it is required that the best available techniques (BAT) for the given industry are taken into account, although that standard may not be reached. The European IPPC Bureau of the Institute for Prospective Technology Studies facilitates the exchange of information between experts, industry representatives, and environmental organizations from across the Member States. The third principle of the IPPCD is flexibility, which allows the licensing authorities to consider each facility's unique circumstances in terms of its technical characteristics, its geographical location, and the local environmental conditions. The fourth principle is the right to public participation by making the permitting and monitoring processes transparent.

In order to be granted a permit to operate a firm must do the following, as quoted from the IPPC website:

a) consider the use of best available techniques for pollution prevention
b) prevent all large-scale pollution
c) use energy efficiently
d) prevent, recycle, or dispose of waste in the least polluting way possible
e) ensure accident prevention
f) return sites to their original state when activity ends

These are ambitious regulations which are inconsistent with everything that the double diversion represents. In theory the requirement to aim towards the use of BAT should not allow for widely disproportional emissions within industries producing homogenous products, when controlled for by size and output. The IPPC Directive defines BAT as follows: "the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole" (Directive 2008/1/EC Article 2). The 'techniques' in BAT refer to not only technology but also the design, maintenance, and operation of a facility. A total of 33 reference documents known as BAT Reference documents (BREFs), some in excess of 800 pages, detail the BATs for each industry.

These reports are not without controversy of their own, as industries themselves have heavily contributed to the reports and some BREFs are said to be strongly influenced by special political interests (Honkasalo et al. 2005). BREFs do not always provide specific emissions levels associated with BATs which can be problematic for facilities aiming to increase efficiency (Honkasalo, Rodhe & Dalhammar 2005). Oftentimes the BREFs do not truly describe the best techniques, but rather "slightly above average" techniques. Moreover, the reports are so dense that only the most competent permit granting authority would be familiar with BATs (C. Dalhammar, personal communication, 22 May 2011). A report by the EC that studied 61 firms in 16 Member States and 12 different sectors indicated that compliance with the BAT requirement is the main problem with the permits that have been issued thus far (EC COM 593 final, 2010). It found that a low percentage of the audited permits fully take into account the BATs as identified in the BREFs. In fact, no explanation could be found for the more than 50% of firms examined which held permits with conditions that diverged significantly from those specified in the BREFs (EC COM 593 final, 2010). In reality, beyond being familiar with all of the BATs, it is a major challenge for permitting authorities to determine the level of compliance with the six requirements listed above. Differences in Members States' permitting standards, as well as the flexibility principle which allows them a fair amount of freedom to make subjective judgments, results in distorted competition throughout the EU; the EC has plans to streamline standards to try to address these problems (C. Dalhammar, personal communication, 24 May 2011).

Implementation of the IPPCD has been problematic. The EC opened infringement cases against Austria, France, Belgium, Denmark, Italy, Greece, Spain, Ireland, Sweden, Slovenia, Portugal, and Malta for their lack of progress in granting permits. All but four of these cases were referred to the European Court of Justice, which ruled against Belgium in 2010 for failing to meet the IPPCD deadline. With this is mind it becomes clear how the extreme level of disproportionality is able to continue in the EU.

4.1.2 REACH

The EU's REACH (Registration, Evaluation, Authorisation and Restriction of Chemical Substances) legislation is the most comprehensive approach in the world to date in efforts to research the effects of individual chemical substances, publicize them, and regulate the chemicals according to the outcomes of the research. While the first EU legislation regarding chemicals tended to aim towards promoting the free trade and distribution of chemicals in the EU, more recent legislation has tended to look towards addressing concerns about human health (Dalhammar 2010). REACH strives to fill the massive knowledge gap about chemicals by placing the burden of carrying out risk assessments on the manufacturers themselves, rather than public authorities. Specifically, REACH aims "to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances" (European Commission 2011). One of the main goals of REACH is to enhance the competitiveness and innovation of the EU chemicals industry. The legislation entered into force on June 1, 2007 and will be phased in over an 11 year period, overseen by the European Chemicals Agency (ECHA) in Helsinki. Greenpeace called REACH "one of the most intensely lobbied pieces of legislation in EU history" (Greenpeace 2006, p.4). In fact, one German chemical company admitted in 2005 that it had 235 German politicians on its payroll (Greenpeace 2006).

Any company operating in the EU that manufactures or annually imports one tonne or more of a chemical substance is required to register it at a central database administered by the ECHA. In order to register the substance it must have a technical report with information on how to safely handle it. Substances used in quantities of 10 or more tonnes must also be accompanied by a Chemical Safety Report which includes details on the guidance of handling it for all identified uses. During the 'evaluation' part of REACH, regulatory authorities examine the information presented during registration to determine whether it has met all of the testing requirements. Substances determined to be of 'very high concern' may be subject to further scrutiny during the 'authorisation' stage of REACH. These substances include carcinogens, mutagens, and substances that cause reproductive harm, that are "persistent, bio-accumulative and toxic", and that are "very persistent and very bio-accumulative" (European Commission 2011). Companies employing the use of any of these substances are required to apply for authorization in order to continue use; authorization is granted by proving that either the socio-economic benefits of the chemical outweighs its risks, or that substances are "adequately controlled" (European Commission 2011). According to the European Commission, the aim of implementing the authorization procedure is to "give industry the incentive to progressively substitute these substances with safer alternatives when technically may be subject to Community-wide restrictions "if its use poses unacceptable risks to health or the environment" (European Commission 2011). Restrictions may also apply to any substance that is produced or imported in volumes lower than one tonne per year, and may range from a restriction on the use of the substance in a single product to a complete ban.

REACH is currently in the fourth year of the 11 year implementation phase. In February 2011 the first group of six "dangerous substances" were identified to be phased out of use in the EU within the next three to five years (European Commission 2011). Just one of the six chemicals, bis(2-ethylexyl) phthalate (DEHP), is included in the E-PRTR and the analysis of toxic releases in this study. Currently there are 46 more 'substances of very high concern' that remain on a candidate list for phasing out, three of which are part of the E-PRTR. The total amount of these four dangerous substances that was emitted (not manufactured) in 2008 is

1,148,906 kg – a miniscule fraction of the total toxic pollution emissions. This signals that at least in the case of these chemicals, although removing them from production should not prove overly burdensome to industry, the rewards of doing so will be great for society.

As all aspects of REACH legislation will not be fully implemented until 2018, the overall impact on EU industries remains to be seen. One-time costs for companies include the registration fee and the cost of researching and writing the chemical reports, known as 'technical dossiers'. Companies may incur further costs in the case that they must apply for authorization, or that they must invest in research and development in order to find suitable substitutes for restricted substances; however based on some of the studies described below, substituting harmful substances in the production process may actually prove to be economically beneficial for many firms.

Beyond the economic aspects, the positive effects on health and the environment could be significant. For example, the California EPA banned the use of toxic chlorinated solvents in the vehicle repair industry due to health concerns. The industry replaced the solvents with products that included hexane and acetone, which turned out to be a neurotoxic blend that resulted in nerve damage in industry workers throughout the state (California Department of Public Health 2011). Banning one harmful substance without full knowledge of its substitutes does little to solve the problem. Successful implementation of REACH should result in far fewer cases like the one in California, not only in the EU but around the world if policymakers pay heed to the publicly available data. The economic benefits of REACH resulting from savings in remediation costs are estimated to be two to 50 times higher than the costs of implementing the program (EEA 2007). REACH is the main legislative tool managed by the European Chemicals Agency. The sketch seen in Figure 4-1 shows the possible decrease in risk from chemicals that REACH may achieve.

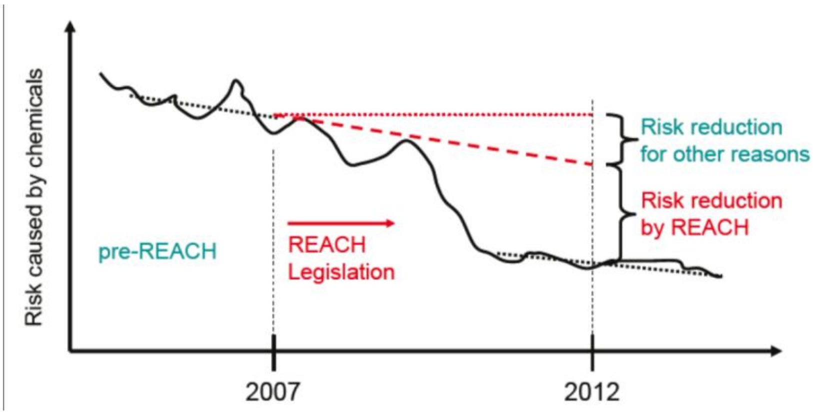

Figure 4-1. Possible evolution of the risk caused by chemicals. Source: Eurostat 2010.

REACH is an incredibly ambitious project by any standards; in an opinion piece titled "Chemical regulators have overreached", Hartung and Rovida (2009) question the feasibility of it all. Although they hail REACH as no less than "the biggest investment in consumer safety ever", they claim that toxicologists do not have the appropriate technology available to them to assess what is required. It was expected that around 27,000 companies would submit 40,000 substances for pre-registration by the time it ended in 2008. Instead, 65,000 companies submitted over 140,000 substances for pre-registration (Hartung & Rovida 2009). REACH aims for the companies to complete testing for these substances by 2018, but until now chemical testing has been done for an average of just 200-300 substances per year (Hartung & Rovida 2009). A model created by Hartung and Rovida (2009) estimates that the final number of substances in REACH after errors and double counting have been taken into account may be around 68,000. They also estimate that this will require the use of 54,000 vertebrate animals for testing. Above all, they declare that "regulatory toxicology needs to move into the twenty-first century", referencing the fact that many standard methods for testing these substances have remained unchanged for the past 40 years (Hartung & Rovida 2009, p.1081). Thus alongside the need for increased testing, there is also a need to advance the testing methodology. Another important issue is monitoring and validating the toxicity data supplied by the industries. There is evidence that some suppliers of chemicals to EU firms still do not know anything about the effects of their products, and thus the firms claim compliance with REACH, hoping not to be audited (C. Dalhammar, personal communication, 22 May 2011).

Given that U.S. environmental regulations comprise 15,000 pages in 16 volumes it is challenging to know exactly which regulations to focus on in the context of the double diversion. The main regulation that has been the center of scrutiny recently is the Toxic Substances Control Act (TSCA). Despite the problems of the IPPC Directive and REACH, they are still more effective regulators of toxics than the TSCA in the U.S. It has not undergone any major revisions since it was passed 35 years ago even though thousands of new chemicals have entered the market. In fact, it only regulates five chemicals or chemical classes out of the 80,000 chemicals used in the U.S. (American Academy of Pediatrics 2011). No pre-market testing is required for any chemicals before they enter the market. When companies are known to have valuable health and safety data about a chemical they are using, many use a loophole to be excepted from publicly releasing the information by claiming that it is confidential. This has led to circumstances where the EPA is aware that a substance or a product may be causing harm, but it is not allowed to divulge the information. Due to laws that favor industry rights, the EPA has been able to require testing on less than 200 chemicals between 1979 and 2005 (American Academy of Pediatrics 2011).

Given the recent attention that has been placed on products containing harmful chemicals, activists and groups such as the American Academy of Pediatrics are campaigning for reform of the outdated and ineffective TSCA. The massive public knowledge base created by REACH may change the way toxics are governed in the U.S. and other places outside the EU, once regulators are no longer able to claim ignorance about the substances. In fact, this has already occurred under limited circumstances: the U.S., China, and other states have had to adapt or adopt legislation due to EU legislation which requires imports to the EU to meet certain standards (C. Dalhammar, personal communication, 22 May 2011). As the world's largest market, certain EU legislation can have substantial ripple effects on other economies. One example of a policy that had such an effect is the Restriction of Hazardous Substances Directive (2002/95/EC) which restricts the use of six hazardous materials in the manufacturing of electronic and electrical equipment.

4.1.3 The precautionary, substitution, and polluter-pays principles in EU environmental legislation

Effective policy for chemicals management requires an integrated approach from a variety of stakeholders. Legislation concerning chemicals has to do with trade, manufacturing, public, health, and the environment, each of which is overseen by different regulatory agencies in most countries. This leaves gaps in the management, and therefore there is a need to improve linkages between such authorities. According to the EEA (2007), "an integrated approach to sound chemicals management" should include three important principles. One is the "substitution principle" to promote the substitution of hazardous chemicals with safe alternatives. The second is the "polluter pays" principle which places the economic burden resulting from negative impacts on the environment and human health on the polluting entity.

The final principle to be included in sound chemicals management policy is the "precautionary principle". To date, implementing any sort of chemicals policy that takes the precautionary principle *fully* into account would simply not be possible without bringing 'business as usual' to a grinding halt. At this time employing the substitution principle would be a much more realistic goal, however once again the lack of data on toxicity of individual substances also impedes the ability to identify suitable substitutes (see Dalhammar 2010 for ways that Sweden has overcome this barrier). Furthermore, industries that are producing seemingly safe products have little incentive to undertake research to find substitutes (unless of course required by REACH). Although these recommendations were made by the European Environment Agency in 2007, EU law does in fact include all three of these principles.

The precautionary principle has been included in European Community laws for almost two decades. In its treaties and texts the EC has declared that precaution should guide all areas of its policy-making (Eckley & Selin 2004). This differs from prevention in that preventionary regulation applies when the effects of the matter in question are already known, and the regulation would prevent harm; with the precautionary principle the effects are unknown. Dealing with scientific uncertainty within the policy realm is tricky – there is almost without exception a noticeable lag between the time when a scientific red flag is raised about a potential danger to human health or the environment, and when policy action is taken to address the risks (Eckley & Selin 2004). In fact Harremoes et al. (2002) confirms policy-makers have been more likely not to implement regulations on something that was later proved to be harmful (a 'type 1' error) rather than erring on the side of caution due to uncertainty about potential effects on human health and the environment.

Eckley and Selin (2004) studied EC regulations related to polychlorinated biphenyls (PCBs) and brominated flame retardants (BFRs) in order to assess the effectiveness of the precautionary principle within the context of these industrial chemicals which are both toxic, persistent, and bioaccumulative. They found that while PCB regulations encountered a fair bit of resistance in the 1980s, BFR regulations were passed in a more streamlined process that "relied strongly on precautionary thinking" (p.96). The states leading the efforts were northern European states, who found that their counterparts in the EC were not as receptive to using the precautionary principle in environmental policy. Sweden for example was called a "leading champion" in pushing for the idea that bioaccumulation and persistence should be sufficient evidence to regulate a substance even when lacking toxicity data (Eckley & Selin 2004). The overall conclusion of the study is that EC environmental regulations would look quite different over the past 15 years had the precautionary principle not been employed. The main factor identified in slowing the process of transferring the precautionary principle from rhetoric into practice is the fact that the burden of proof lies largely with the regulators, not the industrial users of chemicals. This should change under REACH.

While there are no main EU directives regarding the substitution principle, it is a main component of REACH and is established in some national laws. For example in was incorporated into Swedish law in 1985, stating that firms should replace chemicals with less harmful ones when the costs are acceptable (Dalhammar 2010). Yet the substitution principle may be even more controversial in terms on industry interests than the precautionary principle. In fact, in efforts to become more environmentally friendly the chemical industry almost never focuses on substitution, since this requires what are perceived to be sunk costs in the form of research and development (C. Dalhammar, personal communication, 24 May 2011). Instead, industry programs such as the American Chemical Council's "Responsible Care" program focus instead on targets like energy efficiency, which is a worthwhile goal but does not address the core problems specific to the industry. Research shows that policies that restrict or ban the manufacturing or use of certain chemicals have had limited influence on research and development in the chemicals industry (Dalhammar 2010). While employing the precautionary principle is more likely to result in the banning of a substance, the substitution principle can be used to weigh different alternatives. The success of REACH in encouraging the use of the substitution principle by industries will depend on four main factors: a) the quality of the toxicity data, b) the efforts of regulators to audit the data supplied on toxicity and possible substitutions, c) the incentives provided by Member States, and d) preventative efforts (Dalhammar 2010).

In 2004 the EC implemented the Environmental Liability Directive (Directive 2004/35/CE), which introduced the 'polluter pays' principle into EU legislation. The Directive establishes financial liability for any operators that are found responsible for causing environmental damage or contamination. This is defined as direct or indirect damage to the aquatic environment, or to species and natural habitats protected by directives at the Community level; as well as direct or indirect contamination of the land which constitutes a significant risk to human health (EC 2011). This applies to many of the facilities included in this study, such as any activity that discharges heavy metals to the water or air, waste management activities, facilities producing chemical substances, etc. In theory this should serve as a very strong incentive to lower toxic pollution and thus the risk of being held liable for harm. In the coming years after the Directive is fully implemented it will be interesting to evaluate the level of compliance amongst polluters. Despite tough legislation there are certain circumstances that inevitably complicate collection of funds, such as bankruptcy or changeovers in land ownership which makes it difficult to identify the responsible party. The U.S. Superfund cleanup program has had mixed success with collecting funds from the responsible parties throughout its history. In 1995, around 70% of the cleanup costs were being paid for by industry, with 30% coming from taxpayers. The polluter pays legislation failed to be renewed under the G.H.W. Bush administration, leaving Congress to appropriate funds for Superfund from its general revenues each year (Wolk 2004).

4.2 Does environmental regulation hurt industry?

A lingering question that was briefly addressed in Chapter 2 remains whether or not producing disproportional amounts of toxic pollution are simply an inherent, unavoidable part of some economically valuable industries. Freudenburg refers to this topic as the second diversion in the 'double diversion', what he labels "Privileged accounts: necessary harms, or harmful assumptions about necessity?" In other words, is it futile to point out the disproportionality in industries that have no other way of producing goods that we all need? After all, in today's globalized world the production chain for a single product may include inputs from dozens of companies.

In Freudenburg's study, the highest polluting facility in the entire U.S. was IMC-Agrico in Louisiana. It manufactures phosphoric acid for use in fertilizers, which although are a deeply ingrained part of American agriculture, their necessity for food production is a hotly debated topic amongst those working in the fields of environment and development (Freudenburg 2005). Still, that debate becomes irrelevant upon reading the U.S. EPA's investigative report on measures taken to reduce the facility's environmental impacts following the release of the TRI data. According to the report, gypsum was being created as a byproduct of the phosphoric acid production. The gypsum was then stored outdoors in uncovered stacks, and when it rained the phosphoric acid was flushed out of the stacks and released into the environment. Remarkably simple actions such as reducing the surface area of gypsum stacks, covering them to prevent rainwater from entering, and collecting the water runoff in order to recycle the phosphoric acid resulted in a reduction in total toxic releases of one-third (Freudenburg 2005). Thus, in the case of the single highest polluting facility in the U.S., carelessness and sloppiness were the cause of 37.6 million pounds (17,055,000 kg) of toxic releases to the environment, *not* economic or technological necessity. Of course this is just one facility of millions, but it does serve to show that in some cases, massive pollution reductions can be made in relatively simple ways.

Another argument is that applying too many regulations to industries, especially regulations that include the 'polluter pays principle' for example, would force some firms to go out of business. In fact, there is an abundance of evidence showing that good environmental performance is positively correlated with good financial performance, or at least that good environmental performance has no negative impact on financial performance (Guenster, Derwall, Bauer, & Koedjik 2006; Plouffe, Lanoie, Berneman & Vernier 2010; Wagner & Wehrmeyer 2002; Edwards 1998). For example, a study by the UK Environment Agency found that the share price of the firms in the oil and gas sector that had the highest environmental rating outperformed "laggards" by 12% over a three year period (White & Kiernan 2004).The same study found that the stock prices of EU electric utilities with "above average environmental performance" outperformed average performers by 39% over a three year period, while above average water utilities outperformed others by 4.5%. Figure 4-2 shows the difference in performance among firms in the EU electric utilities sector. Even in the forest and paper products sector where maintaining sustainable standards may be more difficult compared to other sectors, the firms with the top environmental ratings outperformed those with below average ratings by 43% between 1999 and 2003.

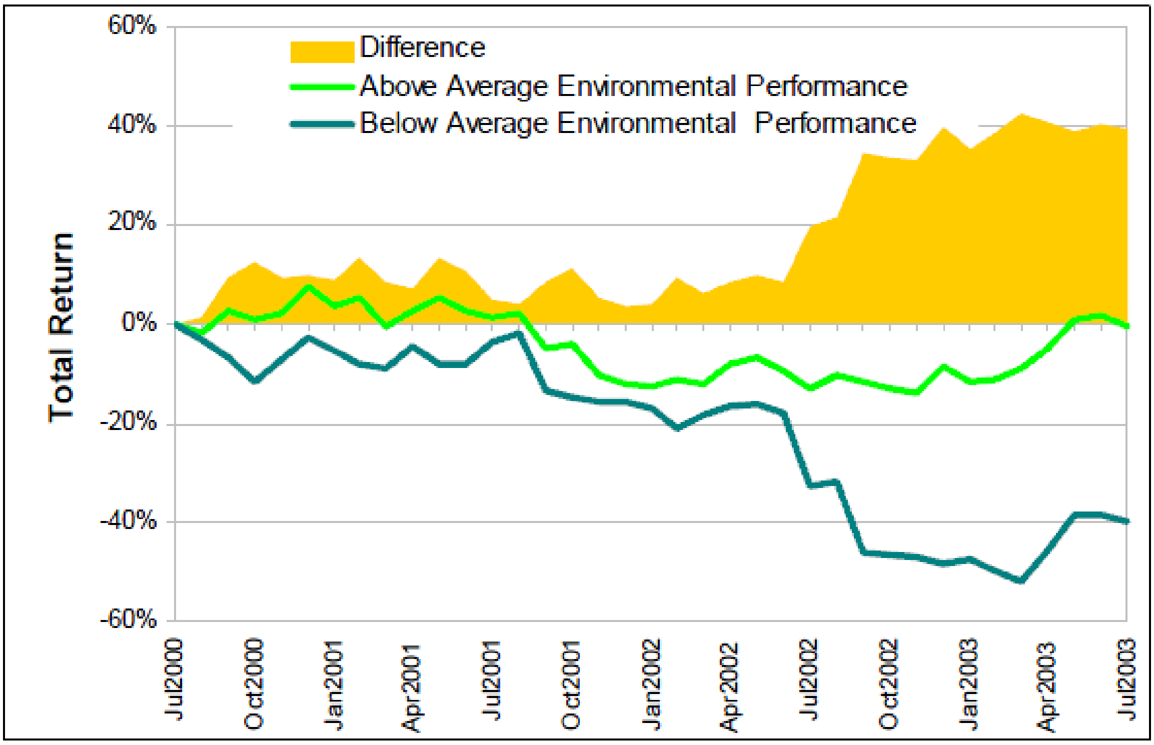

Figure 4-2. Percentage change in total return of environmental leaders versus laggards in the EU utilities sector, 2000-2003. Source: White and Kiernan 2004.

Another common argument is that implementing strict environmental regulations in developed countries will inevitably result in the outsourcing of those industries to less developed countries where such regulations either do not exist or are not enforced, resulting in economic losses in domestic industries and "pollution havens" abroad. Repetto (1995) studied the total share of all manufactures and manufactures from "environmentally sensitive industries[4]" in the U.S., Japan, and five European countries to detect changes between 1970, before most environmental regulations were in place, and 1990. The results are shown in Table 4-1. The countries' overall share in total exports of manufactured goods declined slightly from 74.3% to 72.7% due to further economic growth in the rest of the world; decline in the total share of all manufactures can be explained by the shift in industrialized economies towards the service sector, while the economies of developing countries continued to shift away from agriculture towards manufacturing (Repetto 1995). Yet if environmental regulations were truly driving the most environmentally sensitive industries out of developed countries, the real reductions would be seen in the third column. Interestingly enough, the share in total world exports from environmentally sensitive industries in developed countries declined by just 0.2% from 1970 to 1990. Thus the industries most affected by environmental regulations were able to remain adequately competitive in international trade markets. Repetto (1995) reveals that the industries within the developed countries that experienced the greatest losses in competitive advantage during this time were those that are labor intensive such as the textiles and apparel industries, not those that suffer from the effects of environmental regulations.

Table 4-1. Share of selected countries in total world exports of manufactures of environmentally sensitive goods, 1970-1990. Source: Repetto 1995.

	Total Exports		All Manufactures		Environmentally Sensitive Industries	
Regions/Countries	**1970**	**1990**	**1970**	**1990**	**1970**	**1990**
	(percent)					
Industrial Countries, of which,	74.3	72.7	91.3	81.3	81.3	81.1
Austria	1.0	1.3	1.3	1.6	1.3	2.0
Finland	0.8	0.8	0.9	0.9	2.1	2.4
Norway	0.8	1.0	0.8	0.5	1.9	1.7
Sweden	2.3	1.8	2.9	2.0	4.0	3.4
Germany	11.7	12.2	17.2	15.2	12.1	13.8
Japan	6.6	8.8	10.2	11.8	8.0	8.0
United States	14.5	11.4	16.9	12.3	11.6	10.1

Source: Piritta Sorsa, 1994, Table 2 and Annex Table 2.

In 2004 the European Commission published a report analyzing the impact of cleaner production on employment in the EU. After performing telephone interviews and analyzing case studies and data from 1500 firms in five EU countries that had introduced "environmental innovations", the researchers concluded that on the firm level, such innovations have a small positive effect on employment levels (European Commission 2004). Figure 4-3 shows the level of the effect of each type of innovation on firm employment levels. Innovations that resulted in environmentally products or services had a much greater positive effect than innovations related to the production process (European Commission 2004). Although survey results indicated that economic concerns dominated all others during the innovation process, the top three reasons cited for introducing environmental innovations were to improve the firm's image, to reduce costs, and to comply with regulations. The overall conclusion was that although ecological modernization of these industries should not be seen

[4] The environmentally sensitive industries include pulp and paper, petroleum products, organic and inorganic chemicals, coal mining, fertilizer, cement, ferrous and non-ferrous metals, metal manufactures, and wood manufactures.

as a means to overcome large-scale unemployment problems, it also does not go against labor market policy (European Commission 2004).

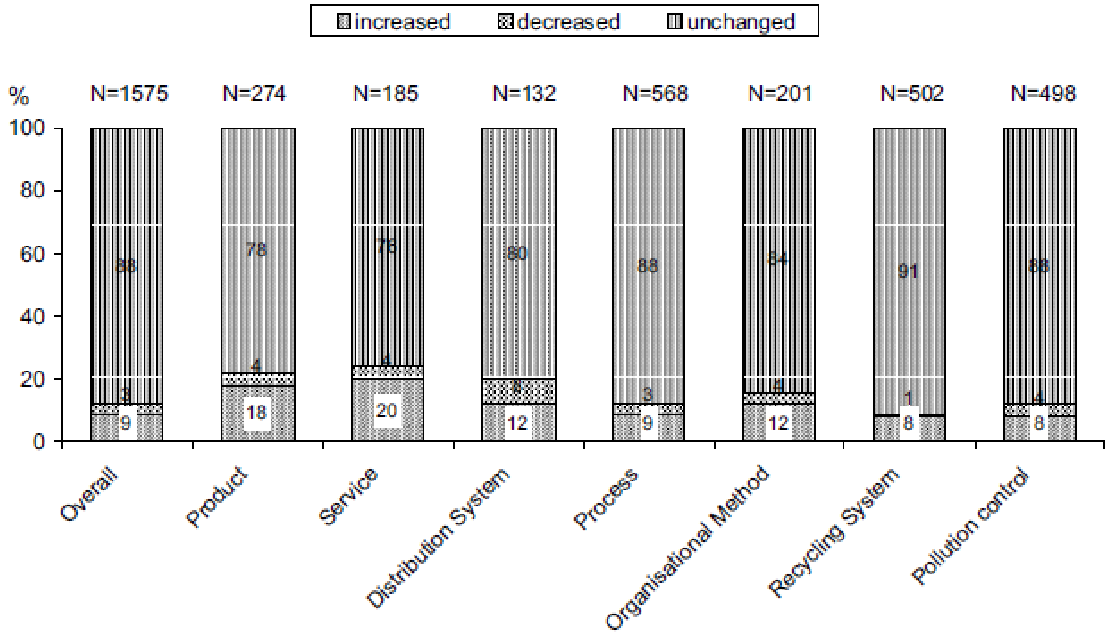

Figure 4-3. The effect of "environmental innovation" on employment at the firm level. The numbers in the white boxes display the percentage increase in employment. Source: European Commission 2004.

Finally, each year the World Bank issues a report titled "Doing Business" in which it examines the business regulations in 183 economies and subsequently ranks them according to the ease of operating a business under such regulations. In the 2011 report, 12 of the EU-27 countries are listed in the top 30 countries for ease of doing business, plus three EFTA countries; 20 out of the 27 countries are listed in the top 50 ranking (World Bank 2011). The United States ranked fifth. Interestingly enough all of the Nordic countries (Denmark, Norway, Sweden, and Finland), which are well-known for being leaders in environmental programs and technologies, are listed in the top 14 rankings out of 183 countries. Therefore although environmental regulations were not the focus of this report, it proves that it is a fallacy to say that environmental regulations will drive business overseas. While that may certainly be a factor in a company's decision to relocate, it is hardly plausible that a company would move for example from Sweden, ranked 14th in the world for ease of business operations, to Vietnam, ranked 77th, due to environmental regulations.

4.3 Effects of pollution registers on emissions trends

A growing body of literature has analyzed the effects of ratings on firms and how they respond to public comparisons of their performance (Scorse 2000; Chatterji & Toeffel 2010; Cohen & Santhakumar 2006). As the TRI has existed for 25 years as one of the earliest and most comprehensive national public pollution registers, a fair amount of research has been done on the uses and effects of TRI data for the general public as well as the private sector. An overview of this research is useful in order to discuss how the much younger E-PRTR may be used as an effective policy instrument in the EU, by both governmental and non-governmental organizations, based on the experience of the TRI. Since the introduction of the TRI, total reported toxic emissions have fallen dramatically in the U.S. Between 1988 and 1997 total reported emissions fell nearly 63%, and between 1998 and 2001 they decreased by an additional 19% (due to expansion of the TRI in 1998 it is not possible to compare aggregate emissions from the entire time period) (Scorse 2000). Moreover, it has been found that firms that emit highly carcinogenic chemicals have reduced those types of emissions more than firms that emit less toxic substances, even when not required by regulations to do so (Scorse 2000).

Scorse (2000) endeavored to study whether the public availability of emissions data from the TRI is at least partially responsible for the dramatic decrease. Starting in 1998, seven additional industries were required to report to the TRI. This meant that many facilities that had been on the "Top 10" polluter lists in many states were suddenly removed from the lists to be replaced by facilities in the newly reporting industries. Scorse (2000) made a model to study those companies that were removed from the "Top 10" lists and found that with less incentive to lower pollution, they reduced emissions by hundreds of thousands of pounds less than they would have had they remained on the "Top 10" list (Scorse 2000). According to Scorse (2000), there is an overall consensus in the literature that "the TRI has greatly influenced firm behavior" and that at least in part, the reductions in TRI emissions are "directly tied" to the public release of the data (p.7).

In fact, the Atlantic Monthly wrote that "The day it became clear that disclosure was a powerful regulatory tool was June 20, 1988, when Richard J. Mahoney, then head of Monsanto (one of the biggest chemical manufacturers in the U.S.), made a dramatic claim. Mahoney said bluntly that he had been astounded by the magnitude of Monsanto's annual release of 374 million pounds [169,643,546 kg] of toxins. He vowed to cut the release of air emissions 90% worldwide by the end of 1992" (Graham 2000). Indeed, between 1988 and 1992, Monsanto's reported emissions to the TRI dropped by 94% (Scorse 2000). There is speculation that companies have switched over to using chemicals that do not require reporting to the TRI in order to remain out of the spotlight, however this hypothesis requires further testing (Scorse 2000). If this hypothesis is true however, this could prove to become a larger phenomenon throughout the EU where emissions from only 48 toxic chemicals (91 total) must be reported as opposed to the TRI's 593.

Voluntary emissions reductions schemes have been another positive side effect of the TRI. With all of the backlash by politicians and industry groups claiming that environmental regulations hurt business, it seems curious that some firms would enter into voluntary emissions reductions agreements with regulatory agencies. Many firms did just that with the U.S. EPA's 33/50 program, which aimed to reduce the release of 17 toxic pollutants by 50% between 1988 and 1995. The EPA invited 8,000 firms to participate, 1,200 of which agreed. Arora and Cason (1996) studied the participating firms' motivation for signing up for the program. The 33/50 program actually began as a response to public outrage following the first release of the TRI data in 1989. Several public interest groups placed a prominent full-page advertisement in the *New York Times* listing the top 10 corporate polluters to land, air, and water (Arora & Cason 1996). Following this, several of the firms named in the advertisement approached the EPA with a desire to pledge to reduce their emissions. Obviously, public relations is a major factor for firms that agree to a voluntary pledge. Cost savings was another motivation; for example, many of the chemicals included were toxic solvents, some of which could be substituted by alcohol or even water, resulting in significant savings. The results were promising: between 1992-1993, participating firms reduced emissions of the targeted chemicals by 20%, while non-participating firms reported reductions of less than 1% (Arora & Cason 1996). Large firms with the highest emissions levels were most likely to participate in the program. Despite the success of this program, it remains clear that those firms who are motivated to participate in voluntary programs are in the minority. In the EU, the results of voluntary programs may be a main reason why policymakers have shifted towards mandatory standards. Examples of this are recent policies that regulate energy efficiency in buildings and carbon dioxide emissions from vehicles (C. Dalhammar, personal communication, 22 May 2011).

Hamilton (1995) cites three reasons why investors in publicly traded companies may be concerned about pollution levels: a) the "loss of goodwill" associated with high pollution emissions, b) the potential cost of future liabilities arising from pollution, and c) the costs of complying with regulations to reduce emissions. Konar and Cohen (2001) found that for every 10% reduction in toxic pollution emissions of major manufacturing firms in the S&P 500, it experiences a USD $34 million increase in the value of its intangible assets. Of the 223 firms in the study, they had an average liability associated with environmental performance of $380 million. This is a major motivation for firms to not only comply with government imposed environmental regulations, but to even go beyond the regulatory standards. Unfortunately most firms continue to take the risks associated with environmental liabilities, and industry lobbies will not cease to protest against environmental regulations anytime soon. The evidence amassed by researchers like Hamilton has yet to be incorporated into corporate business strategies.

Public relations concerns amongst EU industries arising from the publishing of emissions registers data has not been clearly documented in Europe as it has in the U.S. There is also no evidence of any public outrage in Europe comparable to what prompted the voluntary emissions reductions in the U.S. There are notable political differences that help to partly explain this. European citizens rely more upon government authorities to protect public interests, while non-governmental organizations play a more active role in this in the U.S. Firms in the EU may be less reluctant to have emissions data be made public since there is a lower risk of consumer campaigns or lawsuits as compared to the U.S. (C. Dalhammar, personal communication, 22 May 2011). Still, the lack of public response to the E-PRTR may indicate that it is an undervalued resource within the EU.

4.4 Recommendations

Although it is challenging to pinpoint exactly what components of the environmental regulations (or perhaps lack of them) allows the double diversion to perpetuate in the U.S. and the EU, this discussion has attempted to identify a few specific reasons for why this still occurs despite the countless regulations in place. Whether or not one agrees that there are "technological imperatives" for certain products that require highly disproportionate levels of pollution in the manufacturing process, this does not explain within group variations on the level seen within individual U.S. and EU industries.

Therefore at this time the most appropriate recommendation would be to suggest further studies into the level of disproportionality in the EU. As the field of disproportionality research is still young, a great deal more research must be done in order to fully establish the theory's legitimacy. As this report provides preliminary information on the EU-wide level, it would be useful to conduct national level studies which are more likely to have the advantage of national databases that can provide more detailed data on employment, output, expenditure, etc. than is available on the aggregated EU-wide level. Furthermore, as the latest data from the E-PRTR was just released in May 2011, it is now possible to replicate this study using data from 2009 in order to look for trends in disproportionality in the EU across more than just one reporting year.

Identifying individual facilities from the database for the purpose of conducting in-depth examinations of their production practices and emissions level would provide valuable new insights and evidence for the double diversion. As the current evidence stands, this study and Freudenburg's 2005 study provide figures based on massive data sets that only leave us to hypothesize what could cause such incredible differences in emissions levels between seemingly similar firms. Therefore comparing for example several BASF facilities (the largest chemical company in the world with only 0.3% of all EU toxic emissions) with several of the top polluters within the chemical sector would likely provide valuable insights into both the assumptions and conclusions of the double diversion theory as well as the operating environment of these facilities. Or as has already been discussed, comparing Irish and Italian chemical facilities with Spanish and German ones would also likely provide important information about the relationship between toxic emissions and contribution to GDP.

In places where disproportionality has already been established, it would be very interesting to study the relationship between facilities that have both characteristics of the double diversion, and the communities that surround them. It would not be surprising if these areas coincide with the local pollution havens identified by Matthews (2011).

Once REACH has been fully implemented it would be interesting to conduct a study to specifically determine what effect if any the program has had on disproportionality in the EU, especially as manufacturers begin the process of substituting banned and restricted chemicals in the production process. Using Freudenburg's method of recalculating emissions based on toxicity instead of weight, researchers would be able to determine if REACH successfully reduced the risk factor associated with toxic pollution, even if for example substitutions resulted in increased emissions when measured in kilograms.

In the future when more such information has been analyzed, testing for disproportionality within industries could be a valuable regulatory tool for pollution reduction. Although it is less of an issue in the EU, in many countries environmental regulation does not receive optimal funding or priority within the government structure. Identifying instances of the double diversion has the potential to allow regulatory officials to focus their limited resources on only around the top 10% of facilities to receive maximal reductions in pollution, as opposed to spreading their energy across the rest of the 90% of facilities that operate largely within reasonable pollution standards.

5 Conclusion

This report provides the first examination of the trends of Freudenburg's theory of the double diversion in EU industries. The results of this exploratory study are remarkably similar to Freudenburg's, despite the differences in the raw data such as the number of pollutants included. Therefore it can be stated that the EU displays similar levels of disproportionality in industrial emissions of toxic pollutants. While most of the data displayed similarly high levels of disproportionality compared to the U.S., the Gini coefficient calculated for all facilities releasing toxic emissions in the EU was astoundingly high, indicating a critical need for further research in this area to help pinpoint more specifically the driving factors of the double diversion.

The disproportionality theory framework provides an alternate discourse to the frequent dialogue about the impact of individual consumption levels on the environment. This research is not to say that individual efforts are unimportant, but that in terms of overall significance, shifting the focus towards a select handful of industrial polluters may result in more considerable, measurable results, at least in regards to toxic pollution. Freudenburg does not reject the notion "that there are too many of us and we all use too much", but rather he argues that it if we want to see tangible, measurable changes on a large scale then it makes sense to focus these efforts on industry. Furthermore, it is much easier from a regulatory standpoint to regulate and monitor point-source emissions from facilities as opposed to individual people. If individuals continue to do their part to live in an environmentally friendly way, *in addition* to the reductions in pollution emissions that could result from acting on the double diversion, then we would indeed see considerable improvements.

Although the literature review for this report overwhelmingly finds evidence to repudiate the familiar claims that environmental regulations are harmful to industry and employment, the debate rages on without signs of ebbing anytime soon, particularly in political discourse. Let us recall Maine Governor Paul LePage's quote from Chapter 1: "Maine's working families and small businesses are endangered," he said. "It is time we start defending the interests of those who want to work and invest in Maine with the same vigor that we defend tree frogs and Canadian lynx" (Kaufman 2011). What Governor LePage and others do not realize is that there is a medium ground where both parties can be appeased. The simple percentages and ratios that tell the story of the double diversion are accessible to the wider public who may not understand technical jargon used in policymaking. Instead of pitting business interests against environmental interests, leaving no room for crossover, policymakers could instead vow to enforce stricter environmental regulations on the most disproportional polluters, allowing the majority of other polluting firms to continue business as usual, while prompting those that pose the greatest risks to human health and the environment to invest in new technologies. The resources saved by overseeing enforcement at only a few select firms can be applied to help promote advancements in technology rather than cleaning up the messes from outdated technology. Reducing disproportional pollutant loads in the workplace and the environment should be effective in helping to reduce the thousands of preventable deaths that result from workplace exposure to toxic substances each year.

The managers of the E-PRTR can learn from the well-established and successful TRI in the U.S., both in terms of data management and collection, and how it can be used to encourage emissions reductions. Now that E-PRTR data from the first reporting year has been available for over two years, non-governmental organizations and regulatory authorities have the possibility to test the use of public awareness campaigns that have enjoyed broad success in the U.S.

Despite the high level of disproportionality in toxic emissions shown in this report, the EU remains the world leader in environmental protection policies. Indeed, with its legislation that includes the precautionary, substitution, and polluter-pays principle, in addition to the most comprehensive attempt to catalog toxicity data, at least on paper the EU has shown that acting in the public interest is a priority. There are changes on the horizon in the EU. The IPPC Directive may be reformed to make standards for emissions permits more uniform; REACH will be fully implemented in seven years; and the E-PRTR will become more accurate and complete with each passing year. With these developments the prospects for decreasing the level of disproportionality in the EU are promising – only time will tell the effects of the policies on the double diversion and any possible lessons for other nations to learn from.

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Appendix 1: Toxic pollutants tested for in this study

1,1,1-trichloroethane
1,2,3,4,5,6-hexachlorocyclohexane (HCH)
1,2-dichloroethane (DCE)
Ammonia (NH3)
Anthracene
Arsenic and compounds (as As)
Asbestos
Atrazine
Benzene
Benzo(g,h,i)perylene
Cadmium and compounds (as Cd)
Chlorides (as total Cl)
Chlorine and inorganic compounds (as HCl)
Chloro-alkanes, C10-C13
Chlorpyrifos
Chromium and compounds (as Cr)
Copper and compounds (as Cu)
Cyanides (as total CN)
Di-(2-ethyl hexyl) phthalate (DEHP)
Dichloromethane (DCM)
Diuron
Ethyl benzene
Ethylene oxide
Fluoranthene
Halons
Hexachlorobenzene (HCB)
Hydrochlorofluorocarbons(HCFCs)
Hydrogen cyanide (HCN)
Lead and compounds (as Pb)
Lindane
Mercury and compounds (as Hg)
Naphthalene
Nickel and compounds (as Ni)
Pentachlorophenol (PCP)
Phenols (as total C)
Polychlorinated biphenyls (PCBs)
Polycyclic aromatic hydrocarbons (PAHs)
Simazine
Tetrachloroethylene (PER)
Toluene
Total nitrogen
Total phosphorus
Trichlorobenzenes (TCBs) (all isomers)
Trichloroethylene
Triphenyltin and compounds
Vinyl chloride
Xylenes
Zinc and compounds (as Zn)

Appendix 2: List of all sub-sectors that reported toxic releases to the E-PRTR in 2008 and total number of facilities per sub-sector

Activity Name	Number of Facilities
1.(a) Mineral oil and gas refineries	95
1.(b) Gasification and liquefaction	13
1.(c) Thermal power stations and other combustion installations	559
1.(d) Coke ovens	17
1.(e) Coal rolling mills	2
1.(f) Manufacture of coal products and solid smokeless fuel	3
2.(a) Metal ore (including sulphide ore) roasting or sintering installations	17
2.(b) Production of pig iron or steel including continuous casting	147
2.(c) Processing of ferrous metals	64
2.(d) Ferrous metal foundries	77
2.(e) Production of non-ferrous crude metals from ore, concentrates or secondary raw materials	165
2.(f) Surface treatment of metals and plastics using electrolytic or chemical processes	181
3.(a) Underground mining and related operations	88
3.(b) Opencast mining and quarrying	26
3.(c) Production of cement clinker or lime in rotary kilns or other furnaces	189
3.(e) Manufacture of glass, including glass fibre	122
3.(f) Melting mineral substances, including the production of mineral fibres	31
3.(g) Manufacture of ceramic products including tiles, bricks, stoneware or porcelain	114
4.(a) Industrial scale production of basic organic chemicals	347
4.(b) Industrial scale production of basic inorganic chemicals	151
4.(c) Industrial scale production of phosphorous, nitrogen or potassium based fertilizers	41
4.(d) Industrial scale production of basic plant health products and of biocides	16
4.(e) Industrial scale production of basic pharmaceutical products	99
4.(f) Industrial scale production of explosives and pyrotechnic products	9
5.(a) Disposal or recovery of hazardous waste	90
5.(b) Incineration of non-hazardous waste included in Directive 2000/76/EC - waste incineration	80
5.(c) Disposal of non-hazardous waste	69
5.(d) Landfills (excluding landfills closed before the 16.7.2001)	278
5.(e) Disposal or recycling of animal carcasses and animal waste	15
5.(f) Urban waste-water treatment plants	915
5.(g) Independently operated industrial waste-water treatment plants serving a listed activity	41
6.(a) Production of pulp from timber or similar fibrous materials	91
6.(b) Production of paper and board and other primary wood products	119
6.(c) Preservation of wood and wood products with chemicals	3
7.(a) Intensive rearing of poultry or pigs	5032
7.(b) Intensive aquaculture	252
8.(a) Slaughterhouses	60
8.(b) Treatment and processing of animal and vegetable materials in food and drink production	181
8.(c) Treatment and processing of milk	78
9.(a) Pretreatment or dyeing of fibres or textiles	21
9.(b) Tanning of hides and skins	1
9.(c) Surface treatment of substances, objects or products using organic solvents	59
9.(d) Production of carbon or electro-graphite through incineration or graphitization	13
9.(e) Building of, painting or removal of paint from ships	5

Appendix 3: Proportion of selected countries' toxic emissions from the chemical sector versus proportion of total chemical sales (2008 data)

Country	Percent of total pollution within EU chemicals industry	Percent of total EU chemicals sales in 2008
Belgium	4,91	5,80
France	14,52	14,50
Germany	34,87	25,30
Ireland	0,0002	4,50
Italy	0,0012	11,00
Netherlands	7,02	10,20
Spain	14,34	6,70
UK	10,90	10,30
Other	13,27	11,70
Total	100	100

Appendix 4: Gini coefficients within and across selected sectors

Group	Gini Coefficient
Entire database	0.98
Entire database with the top 1.0% of facilities removed	0.92
Entire database with the top 10% of facilities removed	0.57
Emitters of heavy metals	0.91
Subsector 4b: industrial scale production of basic inorganic chemicals	0.92
Subsector 8b: treatment and processing of animals and vegetable materials in food and drink production	0.94
Chemicals sector	0.97
Subsector 3b: opencast mining and quarrying	0.93
Subsector 7a: intensive rearing of poultry or pigs	0.65