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Environmental Leadership? Comparing regulatory outcomes and industrial performance in the US and the EU

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Abstract

There is a widely held view that in the period since the early 1990s the European Union (EU) has overtaken the United States (US) as the leader with the most advanced or demanding environmental regulations. However, it is striking that there are very few robust comparative evaluations of the outcomes of environmental regulations or of levels of industrial environmental performance in the EU and the US. This paper seeks to address this by comparing the standards and levels of performance achieved based on a case study of the regulation of a classic air pollutant (benzene) from a widespread industrial sector that has been heavily regulated in both settings for many years (oil refineries). Contrary to expectations, we find that on average normalised levels of emissions from EU refineries are three times higher than those from US refineries, and whilst outcomes in the US show marked convergence towards the best standards, there continue to be wide variations in the outcomes achieved in different EU Member States, despite the rhetoric of harmonisation.

Keywords: Environmental leadership; environmental regulation; environmental performance; PRTRs; oil refineries.

1. Introduction

The United States and the European Union represent two of the most industrialised and economically developed political entities capable of providing global environmental leadership. In the field of environmental policy, the two actors have taken turns in doing so ever since environmental issues first emerged on domestic and international agendas in the late 1960s. The US made enormous strides in this arena during the early days of global environmentalism in the 1970s, whilst the EU has made significant progress in the development of environmental policy since the 1990s.

Internationally, the US championed an array of global treaties and agreements in the 1970s and 80s, such as the 1973 Convention on International Trade in Endangered Species (CITES) and the 1987 Montreal Protocol on Ozone Depleting Substances (Kelemen, 2010). However, the political dynamics of international environmental policy shifted dramatically during the period that led to the 1992 'Earth Summit' in Rio de Janeiro. US reticence encouraged the EU to assume a leadership role in multilateral environmental politics and ever since it has been widely celebrated as the actor carrying 'the sustainable development flag on the international scene' (Lightfoot and Burchell, 2004: 337). Indicatively, it took the lead in pushing for the adoption of the 1997 Kyoto Protocol on climate change and the 2000 Cartagena Protocol on Biosafety (Bretherton and Vogler 2006). In the course of the past two decades, the EU has ratified every single major international environmental agreement, in marked contrast to the US that has overwhelmingly refrained from entering into new international environmental regimes (Kelemen and Vogel, 2010). Indeed, as Vogler and Stephan (2007: 394) note, the EU has developed competencies across a range of environmental policy areas and is signatory to more than 60 multilateral environmental agreements.

Apart from being at odds over an array of high-profile global environmental issues, the two actors have also followed divergent paths over time with regards to the field of domestic environmental law and regulation. During the 1970s and 1980s, the US enacted a flurry of regulatory statutes aimed at addressing problems of water, soil and air pollution, widely considered as the most innovative, comprehensive and stringent worldwide (Kelemen and Vogel, 2010). Starting however with the administration of George H. W. Bush (1989-1993), US leadership has gradually faded and the country is nowadays widely castigated for lacking an ambitious environmental policy orientation. For instance, the Clinton administration was only able to enact a handful of federal regulatory laws, due primarily to opposition from a Republican-held Congress that was increasingly hostile toward environmental regulations (Vogel, 2003; Kelemen and Vogel, 2010). The Presidency of George W. Bush (2001-2009) saw no new regulatory initiatives, while a number of its administrative rulings actually weakened existing standards or their enforcement provisions (Kelemen and Vogel, 2010).

In addition to the transformation of the EU into a leader in international environmental politics, the 1990s also saw Europe steadily assuming the place of the US as a domestic regulatory 'hegemon' (Bach and Newman, 2007: 828). EU environmental policy gained momentum following the creation of the Single Market and the formal recognition of environmental protection as part of the legal competence of the EU by the Single European Act of 1987 (Hildebrand, 1992). Domestic environmental policy has since evolved into one of the most rapidly expanding areas of EU activity, effectively shaping the nature of global market rules (Jacoby and Meunier, 2010). The European legislative corpus is currently considered amongst the most advanced and progressive worldwide in a range of areas, from greenhouse gas emissions trading to recycling, biosafety and eco-labelling (Falkner, 2007).

Attempts by scholars to account for this shift in US and EU positions rest primarily on linkages between international and domestic environmental agendas. To offer a few examples, Sbragia and Damro (1999) argue that while the US Congress has been facing difficulty in accepting the economic implications of the aforementioned linkages, many EU Member States have instead grown increasingly willing to further consolidate the European experiment through supporting, for example, the gradual expansion of the environmental competences of the European Commission. In addition, differences in the process of institution building are also pertinent in explaining the aforementioned shift. Whereas the US Congress as an institution is not engaged in the actual conduct of international environmental negotiations, the close involvement of all EU actors (Member States, European Commission and Parliament) in the drawing up of international treaties and EU environmental Directives markedly enhances their acceptability, prospects for ratification and likelihood of implementation (Sbragia and Damro, 1999).

Kelemen and Vogel (2010: 427) argue that economic interests provide the most powerful explanation of why the two actors have 'traded places' with respect to exerting environmental leadership. In their view, within the EU domestic electoral pressure from environmentalists since the 1990s has led several (mainly Northern) Member States and therefore the EU itself to adopt stringent environmental policies and standards on a plethora of issues. Subsequently, given the implications for European industries, it was in the competitive trade interests of the EU to champion international agreements that would result in other jurisdictions adopting environmental regulations of a comparative nature. As Carpenter (2012: 253) notes, the rationale behind the EU Member States acting as a group rather than as sovereign states is both to enhance the EU's problematic policy delivery capabilities, as well as to expand its 'sustainability visions and values and extend the remit of its regulations beyond its own borders'. While the exact same process took place in the US during its most active period of environmental legislation in the 70s and 80s, the subsequent weakening of the political influence of environmental lobbies and the sharp decline in the adoption rate of domestic regulations resulted in several US administrations viewing the spread of environmental regulations championed by the EU as incompatible with US national competitive interests (Kelemen and Vogel, 2010).

From the above discussion it is apparent that the EU has made significant efforts to position itself as a leader in environmental policy and to communicate its eagerness to promote the concept of sustainable development on the global scene (Vogler, 2003). Conventional contemporary wisdom sees the EU as a proactive environmental regulator, while the US is usually painted in negative colours, readily given the role of the 'laggard'. Yet, a degree of cautiousness and scepticism is required when interpreting such rhetoric. While the EU has been acknowledged as a leader in certain fields (e.g. biosafety or climate), in others (e.g. agriculture or fisheries) its policies have been associated with particular policy incoherence (Falkner, 2007; Leventon and Antypas, 2012). In addition, as Skodvin and Andresen (2006) rightly point out, what may be praised as a progressive stance during the course of international negotiations might, with the benefit of hindsight, turn out to be quite the opposite. During for instance the early phases of climate talks, the EU advanced to a leading position as a vehement critic of the US-advocated market-based approach to emissions reductions (see Afionis, 2011). Paradoxically, the EU is nowadays attempting to pioneer their development through its domestic emissions trading scheme (Skodvin and Andresen, 2006; Rayner and Jordan, 2013).

In terms of domestic regulatory politics, Vogel (2003) notes that even though the adoption rate of important federal environmental laws has substantially decreased, the US has not ceased regulating. The comprehensive statutes of the past are still in effect and a number of significant regulations continue to be issued pursuant to them (Vogel, 2003). Other authors (Weiner, 2004; Weiner and Rogers, 2002) argue that while there are areas in which the EU has adopted a more precautionary stance (e.g. air toxic substances or genetically modified organisms), there are other areas in which the US has actually outpaced the EU (e.g. particulate air pollution, nuclear energy or ozone-depleting substances). In comparative studies of EU and US policies with regards to automotive emissions, packaging waste and climate change, Vogel (2012) and Vogel et al. (2012) note that while US regulations in the latter two fields are substantially weaker than EU ones, when it comes to automotive emissions standards, the American ones remain stricter.

While there is a significant corpus of work on the stringency and impact of environmental regulations, as well as on the variability of industrial environmental performance, there is a surprising lack of comparative studies looking at actual public wellbeing and environmental outcomes across different countries and over time. One reason for this lacuna is the absence of data that could facilitate the making of such 'like for like' comparisons. As Gouldson et al. (2014) note, data sets differ from one country to another and over time and it is quite difficult and time-consuming to generate normalized measures of performance that would enable robust comparisons to be made.

However, undertaking such evaluations of outcomes and performance is critically important. While the expectation might be that regulatory standards would have a direct impact on industrial performance, it is often the case that governments promulgate strict regulatory standards on paper and then are unable to enforce them in practice (see Gouldson and Murphy, 1997; Jordan, 1999). For standards to have a positive impact they need to be implemented, enforced and complied with. While there can be economic reasons for some companies to go beyond compliance, we can expect properly implemented and enforced regulatory standards to set a minimum level for industrial environmental performance. Surprisingly, while such levels of performance reflect important 'regulatory realities', they are rarely evaluated through international comparative research (Gouldson and Murphy, 1997).

The purpose of this paper is to add to these debates by examining trends in a particular area of industrial environmental regulation and performance, namely emissions of benzene from oil refineries. Classified as a human carcinogen (Bulka et al., 2013), benzene is among the most widely monitored and intensely regulated air toxics in the world. By focusing on this pollutant and sector, we enable the generation of the large-scale data set needed to conduct a comparative analysis of international trends over time. Whilst of course we are aware that we cannot necessarily draw wider conclusions from a focused analysis, we argue that the results offer some rare insights that are of great relevance in widespread and politically charged debates that are often characterized by a lack of evidence. The paper is structured in the following way. In the next section, we consider the relevant regulations that are in place in the US and the EU. We then outline the methodology employed for data collection and analysis, before presenting our findings on regulations and industrial performance and discussing their significance. The paper concludes by suggesting that this case offers evidence that contradicts much of the rhetoric on environmental leadership in the EU and the US.

2. Regulating refinery benzene emissions

This study focuses on emissions of benzene from oil refineries. Benzene is a greenhouse gas and a toxic pollutant with significant impacts on public health and the environment (EEA, 2012). Health effects from exposure to benzene include increased risk of developing cancer, various forms of damage to the immune system, as well as an array of neurological, reproductive, developmental, respiratory and other health complications (EPA, 2012a). Feitshans (1989) notes that the risks of acute or chronic exposure to benzene were identified as long ago as 1900. Its occupational use is highly regulated, with the US Occupational Safety and Health Administration (OSHA) limiting workplace exposure to benzene in the air to 1 part per million (ppm) during the average 8 hour work day or 15 ppm in a 15 minute period (OSHA, undated; see also Capleton and Levy, 2005). Several studies have reported that even though average benzene emissions have declined markedly during the past decade, there are segments of the population in both Europe and the US that are still exposed to relatively high concentrations (see Cocheo et al., 2000; Ballesta et al., 2006; Whitworth et al., 2008; Raun et al., 2009).

While vehicular traffic is the primary anthropogenic source of benzene in the atmosphere (Fruin et al., 2001), refineries constitute the single largest industrial source of benzene emissions. However, industrial emissions are also significant, and benzene emissions from refineries are tightly regulated on both sides of the Atlantic. In the EU, a substantial body of relevant Community legislation has been adopted. The Air Quality Framework Directive of 1996 tasked the European Commission with developing air quality standards and limits for an array of pollutants, including benzene (European Commission, 1996b). These were established through a series of subsequent directives, with the so-called Second Daughter Directive of 2000 establishing a maximum concentration of 5 $\mu g/m^3$ (micrograms per cubic metre) for benzene in air to become mandatory from 2010 (European Commission, 2000b). The Air Quality Directive of 2008 merges the greatest part of the above corpus of legislation into a single directive (see European Commission, 2008). While there is no change to existing air quality objectives, EU Member States are given greater flexibility in the ways in which they comply with certain standards. With regards to benzene emissions, they are allowed to postpone implementation of concentration limits until 2015.

In order to address emissions from industrial installations, in 1996 the EU adopted the Integrated Pollution Prevention and Control (IPPC) Directive. According to IPPC provisions, in order to prevent emissions to air, water and land, Member States must ensure that operators employ the ‘best available techniques’ (BAT), meaning those that have been ‘developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions’ (European Commission, 1996). In order to specify what constitute BAT, the European Commission has developed a technical guidance document for each of the sectors covered by the IPPC Directive, known as BAT reference documents or BREFs (Lange, 2002). Member State regulatory authorities must take BREFs into account when determining BAT for particular installations, but are not bound by them (Lange, 2010). The BREF applying to mineral oil and gas refineries provides guidelines on BAT for controlling air benzene emissions (see European Commission, 2003). In 2010, the EU then adopted the Industrial Emissions (IED) Directive, which is a recast of seven existing pieces of legislation (including the IPPC) and which was to be transposed into national legislation by Member States by January 2013 (see European Commission, 2010). However as of January 2014, only a third of the Member States has successfully completed the transposition process (see European Commission, 2014). One of several significant changes made by the 2010 IED concerns the requirement made upon permitting authorities to demonstrate the manner in which they have taken into account the BREFs, thus rendering them mandatory instead of optional (McLean, 2012).

Although the US has not developed any federally enforceable ambient air standards for benzene, it has determined a concentration level of airborne benzene that is associated with significant health risks, including contracting cancer (Raun et al., 2009). The upper end is an increase of one cancer case in ten thousand people while the lower end is one cancer case in one million people. The 1990 Clean Air Act Amendments also listed benzene as one of 188 Hazardous Air Pollutants and instructed the US Environmental Protection Agency (EPA) to develop emissions standards applicable to a range of industrial sources. In 1995, the EPA promulgated the National Standards for Hazardous Air Pollutants (NESHAP) for petroleum refineries (see EPA, 2000), which require operators to meet emission standards based on the application of 'maximum achievable control technology' (MACT). With regards to benzene, the EPA has investigated several release incidents over the years, with a high-profile case involving a $50 million fine against a BP refinery in Texas for safety violations that included failure to ensure that flares operated at 98 percent efficiency (MACT standard), thus resulting in a significant release of benzene emissions into the atmosphere (Rice, 2012).

Another form of regulation in both the US and EU regards the provision of environmental information through what have become known as Pollutant Release and Transfer Registers (PRTRs). Their goal is to contribute towards greater transparency and accountability on the part of regulatory agencies and businesses through the public dissemination of pollution information (Koehler and Spengler, 2007). This study relied on these publicly available databases in order to estimate refinery benzene emissions in the US and EU. The next section introduces their PRTR systems, details the methodology employed and finally summarizes the range of problems encountered when making use of these informational regulatory instruments.

3. Data sources and methodology

For this study, data on benzene emissions to air from oil refineries in both the US and EU were obtained by making use of publicly available information from PRTRs. These were the US Environmental Protection Agency (EPA) Toxic Release Inventory (TRI) for the period 1990 to 2010, the European Pollution Emission Register (EPER) for the years 2001 and 2004 and the European Pollution Release and Transfer Register (E-PRTR) for the period 2007 to 2010.

Data covering periods up to 20 years was collected for the US and the EU. This is a rather time-intensive task and involves searching through a number of databases to find information on individual refinery emissions, as well as obtaining access to industry information on refining capacities. Emissions data are available online, through a process of selecting year, state, individual refinery, and substance. Multiple searches are necessary to develop the complete dataset, the analysis of which forms the basis of this paper.

The US EPA's TRI was introduced in 1986 as a result of the Emergency Planning and Community Right-to-Know Act (EPA, 2012b). The TRI provides a searchable database offering information on annual releases of over 650 toxic chemicals from a range of industrial sectors. For the purposes of this study we conducted a search by facility, selecting geographic location (state), industry (petroleum) and chemical (benzene). Information on benzene emissions is available for the period 1988 to 2010, in contrast to several other chemicals where it is available only for a much shorter period of time.

The EU EPER was established in 2000 to make emissions data collected through the 1996 IPPC Directive available to the public (see European Commission, 2000a). The EPER published data for the EU-15 (i.e. states which were members in 2001 when EPER came into existence[1]) for 2001 and 2004 before it was replaced by the more comprehensive E-PRTR. As it was published every three years, data published in 2001 and 2004 related to emissions reported in the preceding two years. The E-PRTR covers 65 economic activities within 9 industrial sectors, and provides data for 91 pollutants under 7 groupings. Although the E-PRTR publishes data for 27 EU Member States, together with Iceland, Lichtenstein, Norway, Serbia and Switzerland, to allow us to include EPER data we have only examined refineries in the EU-15. Data on benzene emissions from all facilities emitting more than 1,000kg per year are provided by the EPER and E-PRTR datasets.

The data provided through the US TRI and EU EPER/E-PRTR are typically reported to state/national regulatory agencies by regulated industrial sites. The normal assumption is that the data are collected through a monitoring process that has been approved by regulatory agencies and that companies would face legal sanctions if they were found to have misreported data. However, clearly there is potential for some regulatory agencies to be more demanding or rigorous in their approach to reporting and to the enforcement of associated standards than others (see e.g. Konisky 2009). It is also important to note that PRTR data can be incomplete – the US and EU PRTR schemes started at different times, include different sectors and for a period the EU EPER scheme did not report every year. In each case, PRTR data are also presented as yearly aggregated emissions, making it impossible to link the data to maximum permissible limits and ambient air quality standards with shorter time periods. There have also been controversies in some settings about the reporting of emissions during accidents or phases of maintenance (Ozymy and Jarell, 2011). Whist not perfect, it has been argued that PRTRs provide the best available data and that for some relatively homogenous sectors and emissions streams they enable some robust comparisons of performance to be made both over time and between countries (see Gouldson and Sullivan, 2007).

[1] EU-15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom.

In order to develop a normalised indicator of emissions performance, we divide the total annual benzene emissions to air (in kg) from each refinery by its production capacity (in bcd, i.e. barrels per calendar day). Whilst it would have been better to normalise emissions according to production rather than capacity, refinery specific production figures are not publically available. By using capacity figures, we make the assumption that all refineries should have similar levels of downtime over time. Refinery specific capacity data were obtained from two sources – the Energy Information Administration for US data and the Oil and Gas Journal for EU data (see EIA and OGJ, various years). The list of refineries included in these sources differed in some respects from the list of refineries in the relevant PRTRs. Including only refineries where both emissions and capacity data are available meant that some refineries listed in only one of the two key data sources were excluded from the analysis. Nonetheless, our data set covers 91% of US refineries and almost 96% of total US refining capacity and 51.1% of EU-15 refineries and almost 64.7% of total EU-15 refining capacity in the year 2010.[2] The combined US and EU refineries in this study account for approximately 25% of global operating refineries and close to 30% of global refining capacity for 2010 (see Appendices A and B in the supplementary material for further details of coverage).

4. Results

Figures 1 to 3 present the results of our analysis, with average normalised measures of emissions per unit of capacity for refineries in the US and the EU (Figure 1) as well as for the EU-15 and the Member States (Figure 2) and for the US and the US States (Figure 3). These figures have all been produced using the same scale and for the same time-span to allow for ease of comparison and to illustrate trends in average normalised emissions over time. Regarding Figures 1 and 2, it should be noted at this point that for the intervening years (2002, 2003, 2005 and 2006) no data were available for EU Member States. We have therefore used dashed lines as a visual aid to help the reader see the data points for the years that data were available (2001, 2004).

[2] The results for the EU-15 include only 65% of refineries as refining capacity data were available for some countries, such as Austria, Denmark, Greece and Finland, but emissions data had not been submitted to the EU PRTR.

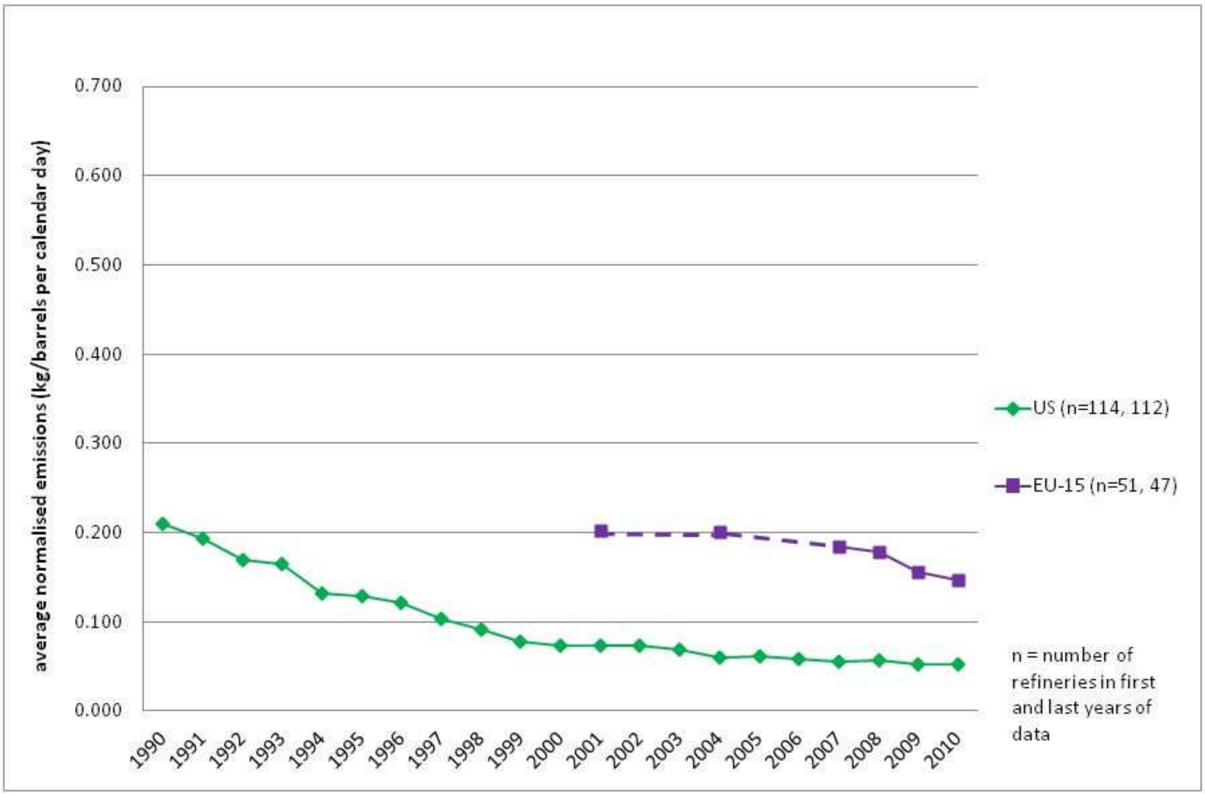

Fig. 1 – Comparison of Average Normalised Benzene Emissions from US and EU-15 Refineries

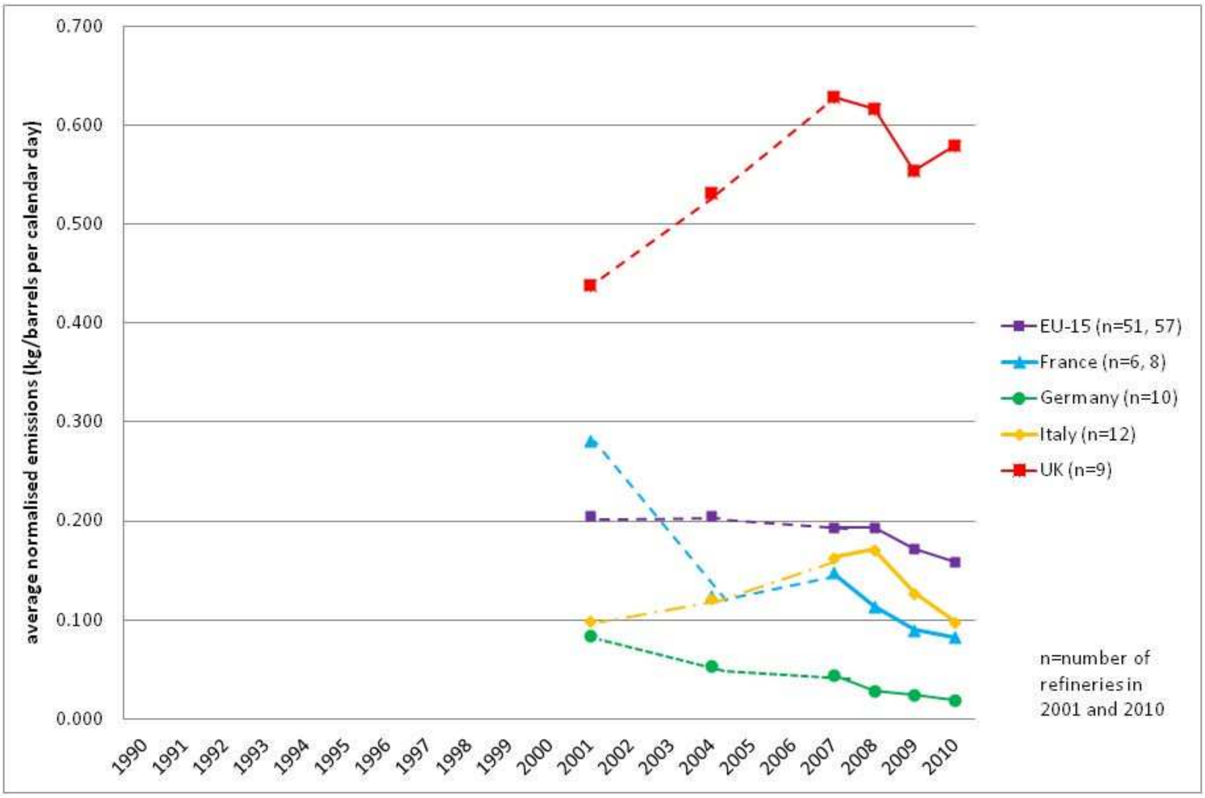

Fig. 2 – Comparison of Average Normalised Benzene Emissions from EU-15 and Member States Refineries

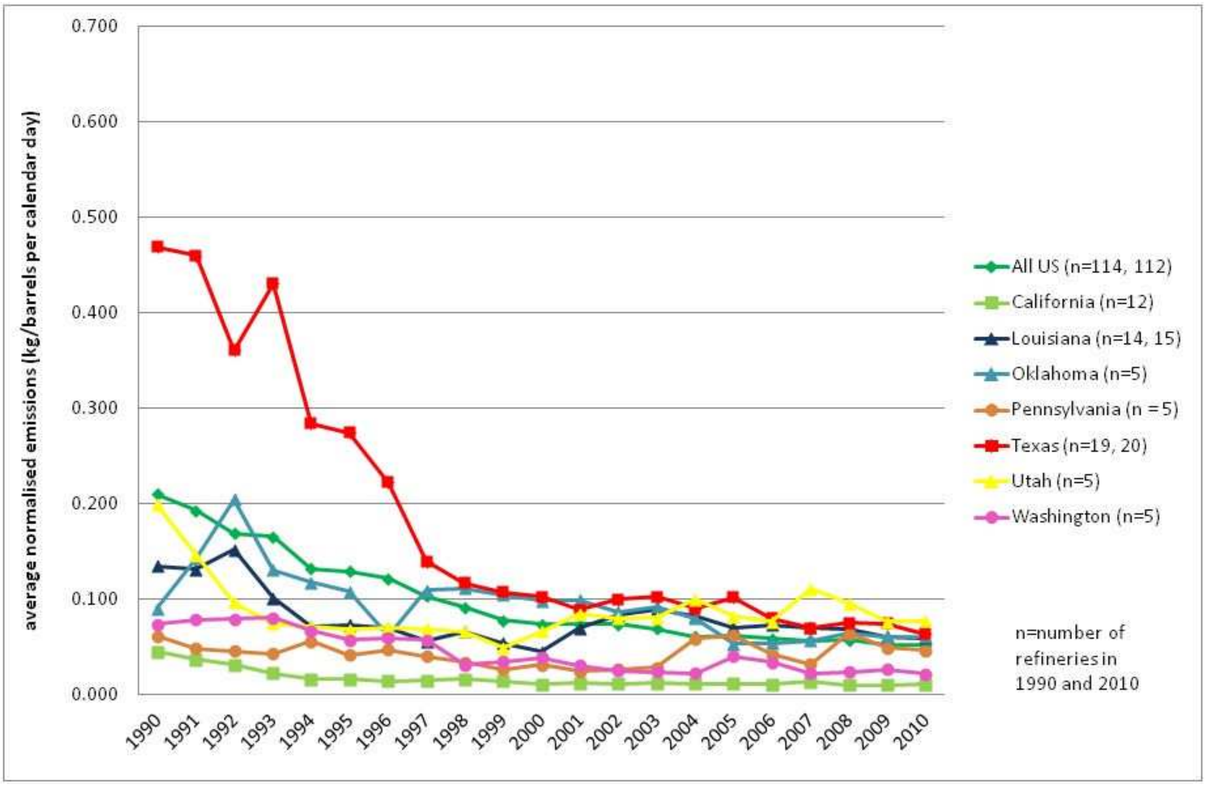

Fig. 3 – Comparison of Average Normalised Benzene Emissions from US and State Refineries

Figure 1 gives a direct comparison between the US and EU-15, showing that for all years where data are available, the aggregated average normalised emissions are substantially higher in the EU-15 than in the US. In 2001, the first year in which data became available for the EU-15, aggregated average normalised emissions were 2.75 times higher in the EU-15 than in the US. For the period 2001 to 2010, aggregated average normalised emissions had fallen by 26% in the EU-15 and 30% in the US, and were 2.8 times higher in the EU-15 than the US.

Some of the reasons for these differences become apparent when we look at Figures 2 and 3 and examine the data in more detail. Before moving on, it should be noted that the EU-15 and US lines in these two graphs include all refineries for which both capacity and emissions data were available. When focusing in on key US states or EU member states, we have included only those US States or EU-15 Member States for which data were available for 5 or more refineries. This reduces the prospect of presenting results that are overly skewed by one key refinery, or by countries with a very small number of refineries, and it also means that we do not over-populate or complicate the graphs. Starting with, Figure 2, we compare aggregated average normalised emissions performance in EU-15 Member States. To make this comparison we use a measure of average normalised emissions to benzene to air in kilograms divided by barrels per calendar day, shown in the figures as “average normalised emissions (kg/bcd)". This reveals major differences in performance between Germany, France, Italy and particularly the United Kingdom (UK). Emissions performance in Germany improved significantly from 0.085 kg/bcd in 2001 to 0.019 kg/bcd in 2010, at which point it was only 36% (just over one third) of the aggregated average performance levels achieved in the US. Emissions performance in France improved significantly in the period from 2001 to 2010, with average normalised emissions falling by 74% from a relatively high level of 0.282 kg/bcd in 2001 to a level that is 3.9 times higher than Germany and 1.4 times higher than the US. Average normalised emissions levels from Italy in 2001 were comparable to those of Germany, and after rising in the period between 2001 and 2007 fell back to levels that were comparable to those realised in France in 2010. The significant outlier that significantly affected the average level of performance achieved across the EU-15 was the UK. Here we see aggregated average normalised emissions levels that increased further from a level that in 2001 was already 2.17 times the EU-15 level and 5.95 times the US level. In 2010, aggregated average normalised emissions levels for refineries in the UK were 31 times those of Germany, 11 times those of the US, nearly 8 times those of France, nearly 7 times those of Italy and almost 4 times those of the EU-15 as a whole. If the UK figures are excluded from the EU-15 total, the UK performs over 8 times worse than the remaining EU-15 Member State average.

Turning to the US, Figure 3 shows a marked convergence in the aggregated average normalised emissions levels achieved in those states with 5 or more refineries in the period from 1990 to 2010. Of the states with 5 or more refineries, California had the lowest emissions levels throughout the study period, and in 2010 had aggregated average normalised emissions that were roughly half of those of Germany in the EU. Emissions levels in the worst performing US States – particularly Texas with its high number of refineries – improved significantly in the period from 1990 when the average normalised emissions level was nearly 11 times that of California, falling to just over 6 times higher by 2010. Although the worst performing state in 2010 (Utah) had an average normalised emissions level that was 7.5 times more than California, it was broadly comparable with France and Italy, was just over half the average level achieved by the EU -15 as a whole and just over one eighth that of the UK.

5. Discussion

These findings are particularly significant for the regulators and operators of oil refineries, and for the communities that live near to oil refineries. They highlight the presence of some significant variations in regulatory outcomes and operator performance. Whilst they do not consider the broader economic or regulatory context, they do suggest that refineries in some settings are much more effectively regulated or better managed than in others. Similarly, whilst they do not assess ambient air quality they do suggest that some populations and communities are much more exposed to the risks associated with this carcinogenic air pollutant than others.

By exploring outcomes, obviously we do not examine causal factors. Despite claims in the wider literature about the diffusion of regulatory standards, technologies, best practices and so on (Dolowitz and Marsh, 1996; Jörgens, 2004), it seems likely that significant variations in these determinants of environmental outcomes remain. Wider governance conditions vary – outcomes are influenced by a wider range of policies, by variable market conditions and by differing blends of media, NGO or community pressure (Holzinger and Knill, 2005). More specifically, regulators have different powers and levels/forms of resources and adopt different regulatory styles in different countries (see e.g. Jordan et al., 2003). Some refineries are older than others and they refine different forms of oil, generate different products and by-products and adopt different management practices and clean or control technologies (Gary and Handwerk, 2001). It is likely that normalised outcomes would be affected by complex and contingent blends of these and other location-specific factors. In the case of the UK, for instance, Gouldson et al. (2014) report that domestic variation in benzene emissions was due, *inter alia*, to some older refineries not having been upgraded for some time or not having invested in augmenting their processes and pollution control technologies. They also note that UK regulators may have greater discretion when interpreting and applying regulations, which could allow them to pay greater attention to economic concerns compared to their counterparts in other EU countries.

Whilst the reasons for the variations in regulatory outcomes or industrial performance need to be better understood, there is still either a common expectation that they should be similar in different contexts or an interest in the reasons why they differ. Our analysis clearly shows that regulators and refinery operators secure better levels of emissions performance for example in the US and Germany than they do in the UK. If higher regulatory standards are associated with the imposition of a competitive disadvantages (Rodrik 1997), then refineries in the UK seem to be deriving a substantial competitive advantage from under-regulation, at least when compared to their counterparts elsewhere in the EU-15 and the US.

In its environmental justice strategies, the US EPA has the goal of offering equal protection to all populations (EPA, 2004). Although we do not explore refinery/location specific levels of emissions or of ambient air quality, our results do suggest that at the US State/EU Member State level, the level of protection from benzene emissions offered to different populations varies significantly. Despite significant convergence in levels of performance over time across the US, residents of California that live in areas affected by benzene pollution from refineries are still better protected than their counterparts in the worst-performing state. But on average exposed communities in the US as a whole are better protected than those in the EU. Within the EU, residents of Germany that live close to refineries receive levels of protection that are comparable to those of their counterparts in the US, but similar residents in France and Italy are slightly less well protected. Residents in the UK are substantially less well protected than either the average for the EU-15 or than those in the US.

More broadly, the analysis indicates that whilst the EU may be the leader when it comes to its support for international agreements or the adoption of new environmental policy instruments, when it comes to environmental outcomes in the domestic field the US retains some ability to surpass the EU. Our findings, therefore, resonate with those of other studies that caution against generalizing when it comes to comparing transatlantic environmental policymaking (Vogel et al., 2012; Weiner, 2004; Weiner and Rogers, 2002). Indeed, our findings contradict the prevailing rhetoric of the EU having taken over from the US as a domestic regulatory 'hegemon' since the 1990s (Bach and Newman 2007: 828).

Our analysis also emphasises the opportunity to improve regulatory outcomes and industrial performance and to promote convergence towards the best standards. In the US, the results suggest that a 'worst first' approach has been adopted by regulators that focuses effort on the worst performing states, but we do not see so many signs of this in the EU where there is a distinct lack of convergence or harmonisation of outcomes in the EU. As we see more limited policy change relating to the case in the US than in the EU, standards do not seem to be improving through the international diffusion of policies. Similarly, as many refineries are owned by multi-national companies, it does not seem that there is an even diffusion of different technologies and management practices. Instead, improved outcomes and performance seem to be being generated through domestic transfers of best practices in implementation.

Our findings could also offer some important insights into the effectiveness of different regulatory styles. There has been some discussion that the US has a peculiarly legalistic and adversarial regulatory style, approximated in Europe mainly by Germany, and that the UK has a peculiarly cooperative and flexible regulatory style that is mirrored in many other contexts in the EU (Lange and Gouldson, 2010). Following Vogel (1986), the presumption has been that these regulatory styles secure equivalent environmental outcomes. But our finding that the US and Germany secure substantially better outcomes than other EU Member States and especially the UK could be an indication that legalistic and more adversarial regulatory styles are more effective in achieving environmental outcomes than cooperative and flexible ones.

6. Conclusions

This paper offers some rare insights into a widespread and often politically charged debate on comparative standards in environmental regulation or industrial environmental performance that is often characterised by a lack of evidence. Whilst we cannot make general claims about the stringency of environmental regulation or levels of industrial environmental performance in the EU and the US based on this focused analysis, we can say that many of the broader claims or assumptions that are made about environmental leadership in the EU and the US are not always true. Instead, the findings of the paper show that the US can be more of an environmental leader than the EU when it comes to regulatory outcomes or industrial environmental performance, that industry in the EU is not always put at a competitive disadvantage by over regulation, that populations in the US may be better protected than those in the EU, that EU policies are not always leading to harmonisation and it is still possible for environmental laggards to exist. These are significant findings. They show that leadership is not only about rhetoric and innovation in policy design, substantial improvements can be delivered by advances in policy delivery, that 'worst first' approaches to the implementation of regulation can deliver sustained improvements in outcomes over time and that adversarial regulatory styles may be more effective in securing better environmental and public health protection outcomes than cooperative ones. All of these findings have significant implications for wider debates on environmental leadership.

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REFERENCES

Afionis S (2011) The European Union as a negotiator in the international climate change regime. *International Environmental Agreements: Politics, Law and Economics* 11, 341-360.

Bach D, Newman AL (2007) The European regulatory state and global public policy: micro-institutions, macro-influence. *Journal of European Public Policy* 14, 827-846.

Ballesta PP, Field RA, Connolly R, Cao N, Caracena AB, De Saeger E (2006) Population exposure to benzene: One day cross-sections in six European cities. *Atmospheric Environment* 40, 3355-3366.

Bretherton C, Vogler J (2006) *The European Union as a Global Actor*, London: Routledge.

Bulka C, Nastoupil LJ, McClellan W, Ambinder A, Phillips A, Ward K, Bayakly, RA, Switchenko JM, Waller L, Flowers CR (2013) Residence Proximity to Benzene Release Sites Is Associated With Increased Incidence of Non-Hodgkin Lymphoma. *Cancer* 119, 3309-3317.

Capleton AC, Levy LS (2005) An overview of occupational benzene exposures and occupational exposure limits in Europe and North America. *Chemico-Biological Interactions* 153-154, 43–53.

Carpenter A (2012) The EU and Marine Environmental Policy: A Leader in Protecting the Marine Environment. *Journal of Contemporary European Research* 8, 248-267.

Cocheo V, Sacco P, Boaretto C, De Saeger E, Ballesta PP, Skov H, Goelen E, Gonzalez N, Caracena AB (2000) Urban benzene and population exposure. *Nature* 404, 141-142.

Dolowitz D, Marsh D (1996) Who Learns What from Whom: a Review of the Policy Transfer Literature. *Political Studies* 44, 343-357.

EEA (European Environment Agency). (2012) *Air quality in Europe — 2012 report*, available at: http://www.eea.europa.eu/highlights/publications/air-quality-in-europe-2012 (accessed May 2013).

EIA (Energy Information Administration). *various years*. Petroleum Supply Annual, Volume 1, available at: http://www.eia.gov/petroleum/supply/annual/volume1/ (accessed August 2012).

EPA (2000) Petroleum Refinery MACT Standard Guidance. EPA-456/B-00-001, available at: http://www.epa.gov/ttn/atw/petrefine/mactdoc1.pdf (accessed August 2012).

EPA (2004) Toolkit for Assessing Potential Allegations of Environmental Injustice, available at: http://www.epa.gov/compliance/ej/resources/policy/ej-toolkit.pdf (accessed January 2014).

EPA (2012a) Benzene, available at: http://www.epa.gov/ttn/atw/hlthef/benzene.html (accessed August 2012).

EPA (2012b) Toxics Release Inventory (TRI) Factsheet. January 2012, available at: http://www.epa.gov/tri/triprogram/TRI_Factsheet_Jan_2012.pdf (accessed August 2012).

European Commission (1996) Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control. *Official Journal of the European Union*. L 257/26.

European Commission (2000a) Commission Decision of 17 July 2000 on the implementation of a European pollutant emission register (EPER) according to Article 15 of Council Directive

96/61/EC concerning integrated pollution prevention and control (IPPC). *Official Journal of the European Communities*. L192/43.

European Commission (2000b) Directive 2000/69/EC of the European Parliament and of the Council of 16 November 2000 relating to limit values for benzene and carbon monoxide in ambient air. *Official Journal of the European Union*. L 313/12.

European Commission (2003) Integrated Pollution Prevention and Control (IPPC): Reference Document on Best Available Techniques for Mineral Oil and Gas Refineries. February 2003, available at: http://eippcb.jrc.es/reference/BREF/ref_bref_0203.pdf (accessed July 2012).

European Commission (2008) Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe. *Official Journal of the European Union*. L 152/1.

European Commission (2010) Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control). *Official Journal of the European Union*. L 334/17.

European Commission (2014) The Industrial Emissions Directive: Transposition of Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control), available at: http://ec.europa.eu/environment/air/pollutants/stationary/ied/transposition.htm (accessed January 2014).

Falkner R (2007) The political economy of 'normative power' Europe: EU environmental leadership in international biotechnology regulation. *Journal of European Public Policy* 14, 507-526.

Feitshans IL (1989) Law and Regulation of Benzene. *Environmental Health Perspectives* 82, 299-307.

Fruin SA, St. Denis MJ, Winer AM, Colome SD, Lurmann FW (2001) Reductions in human benzene exposure in the California South Coast Air Basin. *Atmospheric Environment* 35, 1069-1077.

Gary JH, Handwerk GE (2001) *Petroleum Refining: Technology and Economics*. New York: Marcel Dekker.

Gouldson A, Murphy J (1997) *Regulatory Realities: The Implementation and Impact of Industrial Environmental Regulation*. London: Earthscan.

Gouldson A, Carpenter A, Afionis S (2014) An international comparison of the outcomes of environmental regulation. *Environmental Research Letters* 9, 1-9.

Gouldson A, Sullivan R (2007) Corporate Environmentalism: Tracing the Links between Policies and Performance Using Corporate Reports and Public Registers. *Business Strategy and Environment* 16, 1-11.

Hildebrand PM (1992) The European Community's Environmental Policy, 1957 to 1992: From Incidental Measures to an International Regime? *Environmental Politics* 1, 13-44.

Holzinger K, Knill C (2005) Causes and conditions of cross-national policy convergence. *Journal of European Public Policy* 12, 775-796.

Jacoby W, Meunier S (2010) Europe and the management of globalization. *Journal of European Public Policy* 17, 299-317.

Jordan A (1999) The implementation of EU environmental policy; a policy problem without a political solution? *Environment and Planning C: Government and Policy* 17, 69-90.

Jordan A, Wurzel KWR, Zito AR (2003) 'New' Instruments of Environmental Governance: Patterns and Pathways of Change. *Environmental Politics* 12, 1-24.

Jörgens H (2004) Governance by diffusion – implementing global norms through cross-national imitation and learning. In: Lafferty WM (ed). *Governance for Sustainable Development: The Challenge of Adapting Form to Function*, pp. 246-283. Cheltenham, Edward Elgar.

Kelemen DR (2010) Globalizing European Union environmental policy. *Journal of European Public Policy* 17, 335-349.

Kelemen DR, Vogel D (2010) Trading places: the role of the United States and the European Union in international environmental politics. *Comparative Political Studies* 43, 427-456.

Koehler DA, Spengler JD (2007) The toxic release inventory: Fact or fiction? A case study of the primary aluminum industry. *Journal of Environmental Management* 85, 296-307.

Konisky DM (2009) Inequities in Enforcement? Environmental Justice and Government Performance. *Journal of Policy Analysis and Management* 28, 102-121.

Lange B (2002) From Boundary Drawing to Transitions: the Creation of Normativity under the EU Directive on Integrated Pollution Prevention and Control. *European Law Journal* 8, 246-268.

Lange B (2010) *Implementing EU Pollution Control: Law and Integration*. Cambridge: Cambridge University Press.

Lange B, Gouldson A (2010) Trust-based environmental regulation. *Science of the Total Environment* 408, 5235–5243.

Leventon J, Antypas A (2012) Multi-level Governance, Multi-level Deficits: The Case of Drinking Water Management in Hungary. *Environmental Policy and Governance* 22, 253-267.

Lightfoot S, Burchell J (2004) Green hope or greenwash? The actions of the European Union at the World Summit on sustainable development. *Global Environmental Change* 14, 337-344.

McLean I (2012) Integrated Pollution and Control – the Industrial Emissions Directive. In: Makuch KE, Ricardo P (eds). *Environmental and Energy Law*, pp. 368-392. Oxford, Wiley-Blackwell.

OSHA (*undated*) Substance safety data sheet, Benzene. Occupational Safety and Health Administration Standard Number 1910.1028 App A, Paragraph B.1', available at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10043 (accessed August 2012).

OGJ (Oil and Gas Journals). *various years*. Worldwide Refinery Surveys. PennWell Corporation: Texas US, available at: http://www.ogj.com/.

Ozymy J, Jarrell ML (2011) Upset over Air Pollution: Analyzing Upset Event Emissions at Petroleum Refineries. *Review of Policy Research* 28, 365-381.

Raun LH, Marks EM, Ensor KB (2009) Detecting improvement in ambient air toxics: An application to ambient benzene measurements in Houston, Texas. *Atmospheric Environment* 43, 3259-3266.

Rayner T, Jordan A (2013) The European Union: the polycentric climate policy leader? *Wiley Interdisciplinary Reviews: Climate Change* 4, 75-90.

Rice H (2012) Emails: BP knew of flare problems; $500 billion suit claims that questions raised years before pollutant release in 2010. *The Houston Chronicle*, June 26.

Rodrik D (1997) *Has Globalization gone too far?* Washington, DC: Institute for International Economics.

Sbragia AM, Damro C (1999) The changing role of the European Union in international environmental politics: institution building and the politics of climate change. *Environment and Planning C: Government and Policy* 17, 53-68.

Skodvin T, Andresen S (2006) Leadership Revisited. *Global Environmental Politics* 6, 13-27.

Vogel D (1986) *National Styles of Regulation: Environmental Policy in Great Britain and the United States*. Ithaca, N.Y: Cornell University Press.

Vogel D (2003) The Hare and the Tortoise Revisited: The New Politics of Consumer and Environmental Regulation in Europe. *British Journal of Political Science* 33, 557-580.

Vogel D (2012) *The Politics of Precaution: Regulating Health, Safety, and Environmental Risks in Europe and the United States*. Princeton, NJ: Princeton University Press.

Vogel D, Toffel M, Post D, Aragon NU (2012) Environmental Federalism in the European Union and the United States. In: Wijen F, Zoeteman K, Pieters J, van Seters P (eds). *A Handbook of Globalisation and Environmental Policy: National Government Interventions in a Global Arena*, pp. 321-361. Cheltenham, Edward Elgar.

Vogler J (2003). The external environmental policy of the European Union. In: Stokke OS, Thommessen ØB (eds). *Yearbook of International Cooperation on Environment and Development 2003/2004*, pp. 65-72. Earthscan, London.

Vogler J, Stephan HR (2007) The European Union in global environmental governance: Leadership in the making? *International Environmental Agreements: Politics, Law and Economics* 7, 389-413.

Whitworth KW, Symanski E, Coker AL (2008) Childhood Lymphohematopoietic Cancer Incidence and Hazardous Air Pollutants in Southeast Texas, 1995–2004. *Environmental Health Perspectives* 116, 1576-1580.

Wiener JB (2004) Convergence, Divergence, and Complexity in US and European Risk Regulation. In: Vig NJ, Faure MG (eds). *Green Giants? Environmental Policies of the United States and the European Union*, pp. 73-109. Cambridge, Massachusetts, MIT Press.

Wiener JB, Rogers MD (2002) Comparing precaution in the United States and Europe. *Journal of Risk Research* 5, 317-349.