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An international comparison of the outcomes of environmental regulation

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Abstract
Whilst there is much discussion about the stringency of environmental regulations and the variability of industrial environmental performance in different countries, there are very few robust evaluations that allow meaningful comparisons to be made. This is partly because data scarcity restricts the ability to make 'like for like' comparisons across countries and over time. This paper combines data on benzene emissions from Pollution Release and Transfer Registers with data on industrial production from oil refineries to generate normalized measures of industrial environmental performance across eight Organisation for Economic Cooperation and Development countries and the EU-15. We find that normalized emissions levels are improving in nearly all countries, and that there is some convergence in emissions performance between countries, but that there are still very significant variations across countries. We find that average emissions levels are lower in Japan and Germany than in the USA and Australia, which in turn are lower than in Canada and the EU-15, but we note that average emissions in the EU-15 are significantly affected by particularly high emissions in the UK. These findings have significant implications for wider debates on the stringency of environmental regulations and the variability of industrial environmental performance in different countries.

S Online supplementary data available from stacks.iop.org/ERL/9/074019/mmedia

Keywords: environmental regulation, environmental standards, industrial environmental performance, pollutant release and transfer registers, comparative policy analysis

1. Introduction

There is much discussion on the stringency of environmental regulations and the variability of industrial environmental performance in different countries. Industrial groups frequently claim that regulatory standards for the minimum levels of industrial environmental performance are too high and that this impacts on their competitiveness (cf Ottewell 2012), whilst environmental groups frequently claim that regulatory standards and the associated levels of industrial environmental performance are too low and that this impacts on public health and environmental quality (cf Friends of the Earth 2013). These debates often have a significant political impact—calls for greater levels of environmental protection regularly run into concerns about the impacts of regulation on employment, innovation and competitiveness. These concerns become particularly acute where globalization and liberalization mean that investment and industrial activity can more easily move towards less heavily regulated countries.

Holzinger *et al* (2011) argue that in recent decades there has been a convergence in the environmental standards being adopted by policy makers in developed economies. This convergence could be driven by the internationalization of environmental policy with countries agreeing to adopt similar international standards (Busch and Jörgens 2005), by policy learning and the diffusion of policy instruments and approaches from country to country (Jörgens 2004), or by the diffusion of private standards and new environmental technologies and management practices (Dolowitz and Marsh 1996). From an environmental perspective, it is hoped that there is convergence around higher environmental standards, with countries gradually adopting higher standards over time, but there are also concerns that the competitive implications of environmental policy are leading to a 'race to the bottom' and convergence around lower standards (Holzinger and Sommerer 2011).

Based on the results of large scale surveys of expert opinion, Holzinger *et al* (2011) argue that there has been convergence around an upward trend in environmental standards, and that there has been mobility in international rankings with some laggard countries which had lower environmental standards catching up with and sometimes over-taking the leaders that historically had the higher environmental standards. Over time, the EU has moved from a laggard to a leader and the above argument is often put forward in the EU, where the received wisdom is that the EU has become a leader on environmental protection and where concerns are frequently expressed that EU industry has been put into a competitive disadvantage by over-regulation (Scheelhaase *et al* 2010).

Despite the widespread importance of the debate on the stringency of environmental regulations and the variability of industrial environmental performance, there are very few robust evaluations that allow meaningful comparisons of the actual outcomes of environmental regulations in different countries to be made. One of the reasons for this is that data scarcity commonly restricts the ability to make 'like for like' comparisons of regulatory outcomes and industrial performance across countries and over time. Different data sets are available in different countries, there is a lack of consistent, continuous data over time, and it is hard to generate normalized measures of performance that enable meaningful comparisons to be made (see Gouldson and Sullivan 2007).

However, such evaluations of regulatory outcomes and industrial performance are critically important. Whilst we might expect regulatory standards to impact directly on industrial performance, it is all too evident that governments can adopt tough regulatory standards on paper and then fail to translate them into practice (see Gouldson and Murphy 1997, Jordan 1999). For standards to impact on environmental performance, and then on environmental quality and public health, they have to be implemented and enforced, and regulated companies need to comply with them. Whilst some companies can be expected to go beyond compliance (Gunningham *et al* 2004), for example when there are economic reasons for them to do so, when implemented and enforced we can expect regulatory standards to set a minimum level for industrial environmental performance. These levels of performance therefore reflect important 'regulatory realities', but, surprisingly, they are very rarely evaluated, particularly through international comparative research (Gouldson and Murphy 1997).

In this paper, we seek to address this gap by analyzing emissions of benzene from oil refineries in various Organisation for Economic Cooperation and Development (OECD) countries. We adopt this focus for a number of reasons. Refineries have been present in a relatively common form in many countries for many years, and the basic activities of refineries generate benzene emissions that have been heavily regulated in many countries since the 1970s. There is therefore a meaningful basis for both international and historical comparison. To conduct such an analysis, we require emissions data for a large number of regulated sites in a range of countries over a long period of time. Such emissions data is available through Pollution Release and Transfer Registers (PRTR). In order to develop normalized measures of performance that take account of varying scales of production, we also require site-specific data on the productive capacities of each site. This data is available for refineries through various publically available data sets on the energy industry. Whilst there is a basis for comparison and access to data for this particular sector and pollutant, extensive searches suggested that there are very few other sectors and pollutants where these requirements would have been met. Whilst of course we are aware that we cannot necessarily draw wider conclusions from such a focused analysis, we argue that the results could offer some rare insights that could be of great relevance in widespread and politically charged debates that are often characterized by a lack of evidence.

2. Scope, data sources and methodology

2.1. Scope and focus

The research in this paper was conducted using emissions data from various PRTRs. PRTRs are catalogues or registers of potentially harmful releases to air, water and soil (Bünger 2012). They first emerged in the US, where the Toxics Release Inventory Program was established in 1986 under the Emergency Planning and Community Right-to-Know Act (see EPA 2012). Since then, PRTRs have been adopted in numerous industrialized and a growing number of developing countries (Kerret & Gray 2007). Following the US example, the Canadian National Pollutant Release Inventory was created in 1994, with Australia setting up its National Pollutant Inventory in 1998 and Japan its PRTR in 2001. In the EU, the European Pollutant Emission Register (EPER) was established in 2000 but was subsequently replaced by the European Pollutant Release and Transfer Register (E-PRTR) in 2007. The geographical and temporal scope of the analysis in this paper is determined by the presence (and the dates of inception) of the PRTRs that provide access to the required emissions data. We therefore include the US, Canada, Japan, Australia and the EU-15[1]. We also break the EU-15 data down for those EU member states (France, Germany, Italy, the UK) with more than five refineries and where both emissions and capacity data were available. We look at the EU-15 rather than the wider EU as the early EPER did not provide data from the newer member states that joined the EU after 2004.

PRTR data can provide the basis for examining pollution burdens and trends over time. Consequently, they can be

[1] Member states that were part of the European Union prior to 2004, namely Germany, Italy, France, Spain, Portugal, Luxemburg, Belgium, Netherlands, Greece, Sweden, Finland, Austria, Denmark, Ireland and the United Kingdom.

especially useful tools when conducting comparative analyzes within countries (Sullivan and Gouldson 2007). The data in PRTRs is typically that which is reported to regulatory agencies by regulated industrial sites. In most settings, the data would have come from monitoring protocols approved by regulatory agencies, and companies would commonly face legal sanctions if they were found to have misreported data. However, there is certainly scope for variations in the scope and quality of the monitoring and reporting processes that generate PRTR data—for example there have been controversies in some settings about the reporting of emissions during accidents or phases of maintenance (Ozymy and Jarrell 2011) and there have been suggestions that some regulatory agencies may be more demanding or rigorous in their approach to reporting and to the enforcement of associated standards than others (see e.g. Konisky 2009). PRTR data may also be incomplete—the PRTR schemes of different countries started at different times, include different sectors and some do not report every year. PRTR data is also presented as yearly aggregated emissions, making it difficult or impossible to use the data to assess emissions levels on any particular day (i.e. during an incident) or to link it to maximum permissible limits and ambient air quality standards with shorter time periods. Even so, PRTRs do provide the best data that is available on the emissions performance of some key sectors, and for some relatively homogenous sectors and emissions streams they can enable some robust comparisons of performance to be made both over time and between countries.

Within the confines of the data made available through PRTRs, we focus on oil refineries. In 2010, there were 661 refineries in the world, with a total refining capacity of 87.2 million barrels per calendar day (bcd). Focusing on refineries in those countries with established PRTRs, this study includes data on 275 refineries with a refining capacity of 38.7 million bcd in that year, i.e. 41.6% of world refineries and 44.4% of world refining capacity (see figures 2.1 and 2.2 in the supplementary material). For the US, the study captures over 94% of refineries and 91% of the total refining capacity in 2010. For Australia and Japan, it includes all operating refineries and capacity in that same year. For Canada, it covers 95% of refineries and 93% of refining capacity. For the EU, the study covers 54% of refineries and 64.7% of EU-15 refining capacity. The study includes data on emissions from only those refineries that were operating continuously from the date when PRTR data became available. This has provided us with continuous data for 22 years for the US, and for 16, 12 and 10 years for Canada, Australia and Japan respectively. Far less consistent data is available for the EU, however, as initially it was only available for 2001 and 2004 and then annually from 2007 onwards. In the dataset we only consider refineries with information available on both emissions and refining capacity. As this information is not available for a number of EU refineries, this explains why coverage of EU refineries and refining capacity is at a much lower level than for all the other countries in this study.

We also focus on benzene emissions. Benzene is classified as a human carcinogen (Bulka *et al* 2013), and is among the most widely monitored and intensely regulated air toxics in the world. It is a naturally occurring aromatic hydrocarbon that is a component of crude oil and is released as part of the refining process. All oil refineries risk emitting benzene, and control of benzene emissions from refineries has long been subjected to regulation in developed countries.

Table 1. PRTR Data Sources.

Country	PRTR data source	Years	No. of refineries in study[a]
United States	US Toxic Release Inventory http://www.epa.gov/tri/	1988 onwards	123, 122[b]
EU-15 France Germany Italy UK	European Pollutant Emissions Register (EPER); European PRTR (E-PRTR) Data for both available at: http://prtr.ec.europa.eu/	2001 and 2004; 2007 onwards	EU-15—51, 47 France—6, 10 Germany—10 Italy—12 UK—9, 8
Australia	Australian National Pollutant Inventory http://www.npi.gov.au/	1999 onwards	8, 7
Canada	Canadian National Pollutant Release Inventory http://www.ec.gc.ca/inrp-npri/	1995 onwards	17
Japan	Japan PRTR (data in Japanese only) http://www.env.go.jp/en/chemi/prtr/prtr.html	2001 onwards	31, 30

[a] Where there are two numbers in this column, they represent the number of refineries for which data is available for the first year and in 2010.
[b] While data was available for 123 and 122 refineries for 1990 and 2010 respectively for the US, a number of refineries in Texas and California are on split sites, where refining takes place on two closely associated sites, under the same ownership, but which are physically divided by a road, for example. These are dealt with separately according to the EIA but are combined in TRI emissions data. As a result, the number of US refineries shown in figure 1 is based on the TRI reports (114 and 112 in 1990 and 2010 respectively).

2.2. Data sources, methods and assumptions

The data sources used in this study are outlined in table 1. Oil refineries are located in many countries—and given their size, scale and strategic importance they tend to remain operational over many years. No minimum size has been set for refineries included in this study since their refining capacity can of course change over time—as can their raw material

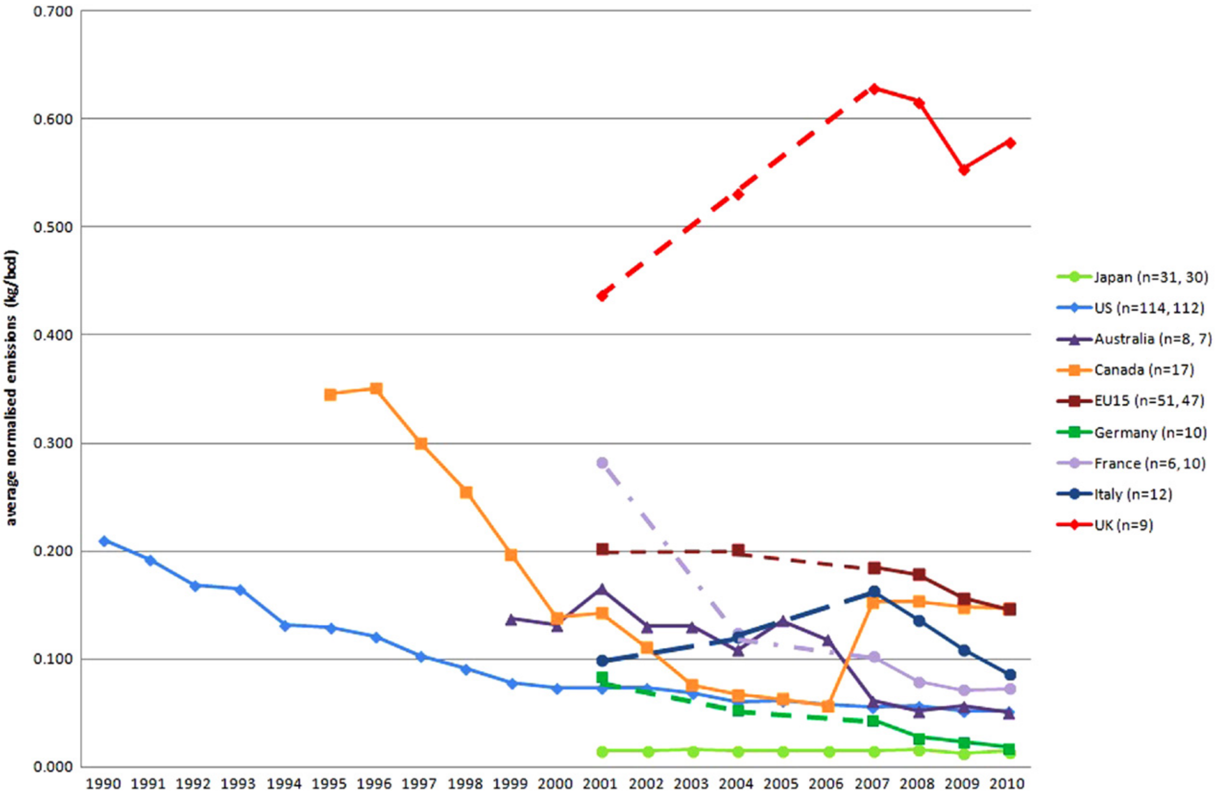

Figure 1. Comparison of normalized emissions measure for refineries in OECD Countries, 1990–2010 (kg benzene/bcd capacity). Note that where two numbers are given in brackets for each country, this represents the number of refineries included in this study in the first year for which data was available and in 2010 (see also figure 3.1 in supplementary material).

feedstocks (e.g. the type of crude oil they refine), their primary product streams (e.g. the petroleum, kerosene or other products they produce) and their application of different process and control technologies or managerial approaches. Whilst we take account of variations in capacity over time, we do not take account of the other variable factors listed above as there is no consistent data available on these. Further information on all country coverage of this study is provided at tables 2.1 to 2.3 in the supplementary material.

To normalize emissions data to take account of the scale and productive capacity of different refineries (and changes in scale over time), we draw on data on refinery capacity. Data on refinery capacities for all countries other than the US was obtained from the Oil and Gas Journal (OGJ) Databooks until 2005 and OGJ Refining Surveys from 2006 onwards (see OGJ, various years). For US refinery capacities, data was obtained from the US Energy Information Administration (EIA) Petroleum Supply Annuals (see EIA various). Capacity is used as a variable rather than production as data on actual production levels is not available. Capacity and production are likely to differ, for instance because of downtime for maintenance or because of accidents. By using capacity figures, we make the assumption that all refineries should have similar levels of downtime over time.

Using emissions and capacity data, we produce a normalized measure of emissions for individual refineries in each year. This is calculated by dividing total benzene emissions to air (in kilograms) by refining capacity measured as barrels per calendar day (bcd). We assume that benzene emissions are monitored and reported in the same way in each of the countries (and within those counties in each of the states or provinces) included in the study. Most fundamentally, given the potential issues with PRTRs described above, we assume that the emissions data provided through the PRTRs in each of the countries included in the study provides a sufficiently robust basis upon which to make meaningful comparisons of emissions performance both over time and between countries.

3. Findings

The main findings of the analysis are presented in figure 1. As can be seen, there is a very significant variation in the average normalized emissions levels in the different countries. Japan is by far the best performing country with average normalized emissions of no more than 0.016 kg bcd^{-1} in any year, stable levels of average performance over time and a worst performing refinery emitting 0.072 kg bcd^{-1} in 2010. Germany is the second best performing country overall with average normalized emissions of 0.018 kg bcd^{-1} in 2010, with performance having improved from 0.085 in 2001 and 0.044 in 2007. The worst performing German refinery in 2010 emitted 0.041 kg bcd^{-1}. In 2010, Japan and Germany achieved average normalized emissions levels that were less than half those of any other country. Australia is the third best performing country, with average normalized emissions improving from

Table 2. Country Rankings (2010) by average emissions per unit of capacity (kg bcd^{-1}) plus worst refinery in 2010.

2010 Ranking	Country	Average emissions in kg bcd^{-1}	Worst single refinery in 2010, emissions in kg bcd^{-1}
1	Japan	0.015	0.072
2	Germany	0.019	0.041
3	Australia	0.050	0.141
4	US	0.052	0.404
5	France	0.083	0.155
6	Italy	0.098	0.252
7	Canada	0.139	1.659
8	EU-15	0.159	1.502
9	UK	0.579	1.502

0.165 kg bcd^{-1} in 2001 to 0.050 kg bcd^{-1} in 2010. The worst Australian refinery in 2010 emitted 0.141 kg bcd^{-1}. The US is the fourth best performing country, with steady falls in average emissions per unit of capacity from 0.209 kg bcd^{-1} in 1990 to 0.041 kg bcd^{-1} in 2010. The worst performing US refinery in 2010 emitted 0.404 kg bcd^{-1}. Ranked seventh, eighth and ninth respectively are Canada, the EU-15 and the UK for 2010. These had average normalized emissions levels that were approximately 7, 8 and 14 times higher than those of Japan and Germany. The UK has the worst emissions value for a single refinery within the EU-15 for all years except 2001 (when a Swedish refinery had an emissions level of 1.736 kg bcd^{-1}). In 2010 the worst performing UK refinery emitted 1.502 kg bcd^{-1}. Table 2 presents these results in more detail (see also figure 3.2 in supplementary material).

Overall it is clear that the best performing refineries are in Japan and the worst are in the UK—average normalized benzene emissions from UK refineries were approximately 37 times those of Japanese refineries in 2010 and the worst UK refinery in 2010 emitted almost 21 times more benzene per unit of capacity than the worst Japanese refinery. While Japan and more recently Germany stand out for their good performance, the UK stands out for its poor performance, helping to ensure that average normalized emissions rates for the EU-15 were three times those of the US in 2010, which in turn were 3.5 times those of Japan.

4. Discussion

Clearly our results depend on both the reliability of the PRTR data underpinning the analysis. As stated above, PRTR data is collected through monitoring protocols approved by regulatory agencies, and any misreporting of data would normally trigger legal sanctions. It can therefore be seen to be quite robust, and it is certainly the best publically available data on industrial emissions, but some potential for variations in the scope and quality of the data remains.

Thereafter, a key question then emerges about the extent to which we can attribute any variations in industrial environmental performance to differences in the regulatory standards applied in different countries. If regulation sets minimum standards that companies generally comply with, then lower performance can only be possible with lower regulatory standards.

It is important to note though that higher performance above these minimum standards need not be because of higher regulatory standards—it could be because various other factors lead to 'beyond compliance' behaviours (Gunningham *et al* 2004). Such behaviours could be adopted because of management cultures and practices, or because of market pressures and technological opportunities. They may also emerge because of private regulations and voluntary codes and standards, or because of social regulation and civic or NGO pressure.

Whilst this could mean that some of the variations in industrial performance are the result of these non-regulatory pressures, we focus on a globalized industry that is populated by large multi-national corporations, and we consider variations in performance at the country rather than company level and only in OECD countries with similar levels of development. As a result, we suggest that these non-regulatory pressures are likely to be broadly similar across all of the countries included in the study. We therefore posit that there is likely to be a direct and observable relationship between industrial performance and regulatory standards, but we recognise that this is an aspect of the research that warrants further investigation in the future.

If we accept these points, then our findings are significant as they reveal significant variations in levels of emissions of a carcinogenic air pollutant from a widespread industrial sector. They are of particular relevance for the regulators and operators of refineries, and for the communities that live near to them. More broadly, of course we recognise the need to be cautious in the extent to which we draw any wider conclusions from a focused analysis. However, we argue that the insights generated could be of great relevance in widespread and politically charged debates about comparative standards in environmental regulation that are often characterized by a lack of evidence, and that they demonstrate the value of such comparative analyses and the need for further research with a similar approach.

A first broader observation is that the results suggest that at least in this case there has been a widespread but not universal convergence in levels of industrial environmental performance in different countries in recent years. Holzinger *et al* (2011) have argued that globalization is leading to a convergence in environmental regulations at a broad scale, and that cross-national diffusion of innovations in environmental policy is widespread, but that there is a lack of systematic knowledge as to whether this results in greater homogeneity of national environmental policies in the long run. Our study does not analyse the design or implementation of national environmental policies, but it does suggest that the outcomes of these policies may be converging, at least in the case of benzene emissions from refineries where we see strong evidence of convergence in emissions performance in recent years.

A second but closely related finding relates to mobility, i.e. the extent to which convergence also coincides with

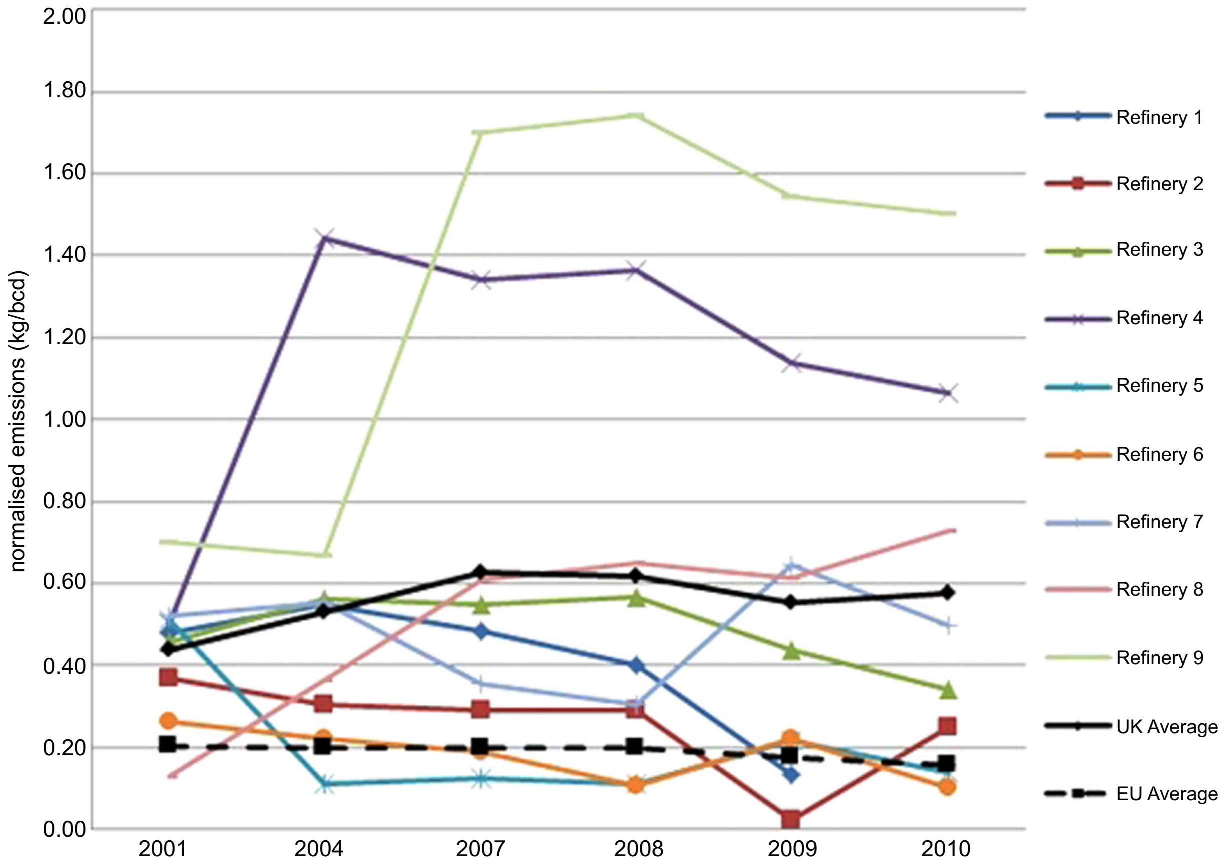

Figure 2. Comparison of normalized emissions measure for UK refineries 2001–2010 (kg benzene/bcd capacity).
NOTES: Refinery number 1 did not report emissions in 2010 and so the UK average in 2010 is for eight refineries rather than the nine for other years. To assist in the readability of this chart the years 2002, 2003, 2005 and 2006 are omitted—average normalized emissions may have varied greatly in those years but no data was collected under the EU-PRTR.

'processes of catching-up and changing rank between leaders and laggards' (Holzinger *et al* 2011). Again, we see clear patterns emerging in our study, with most countries exhibiting steady performance over time, most notably the US, but also France and Australia. Only Germany, however, has so far managed to catch up with the leader, namely Japan. Canada also managed to overcome its laggard position and catch up and even surpass countries like the US and Australia. Since 2006, however, Canada appears to have been unable to keep pace and fell behind, but closer inspection of the data suggests this is due to increased emissions in one refinery. In addition, there is also evidence of 'worst first' regulation being enacted, i.e. bringing worst performing oil refineries into line with the best. This is the case in all the countries under study, apart from the UK and Canada (see figure 1).

A third finding is that despite some level of convergence and catching up, the results confirm that considerable variability can still exist in the outcomes of environmental regulation across different countries. Japan exhibits the best performance by a substantial margin, while Germany ranks second best and is steadily converging with Japan. The US shows a linear improvement over the years, with Australia, France, Italy and Canada converging over time with US standards; the latter though only until 2006. Overall, the results suggest that oil refinery benzene emissions in the UK are substantially higher than in other countries, that emissions across the EU-15 and Canada are twice the average of the US and Australia, which are in turn twice the average of Japan.

Relatedly, a fourth major—but rather unexpected finding—relates to the EU-15 being the main outlier, which contradicts the prevailing rhetoric of it having assumed since the 1990s the place of the US as a domestic regulatory 'hegemon' (Bach and Newman 2007: 828). Indeed, the EU is often seen as a far more 'innovative, aggressive and successful regulator' compared to the US (Rosenbaum 2007: 146). Domestic environmental policy in Europe has over time evolved into one of the most rapidly expanding areas of EU activity, with its legislative corpus being 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). In addition to advertising its environmental leadership credentials, the EU has even engaged in efforts to 'globalize' its environmental regulation by championing international agreements that would result in other jurisdictions adopting environmental regulations of a comparative nature (Kelemen and Vogel 2010). But our results reveal that there are some instances at least where the

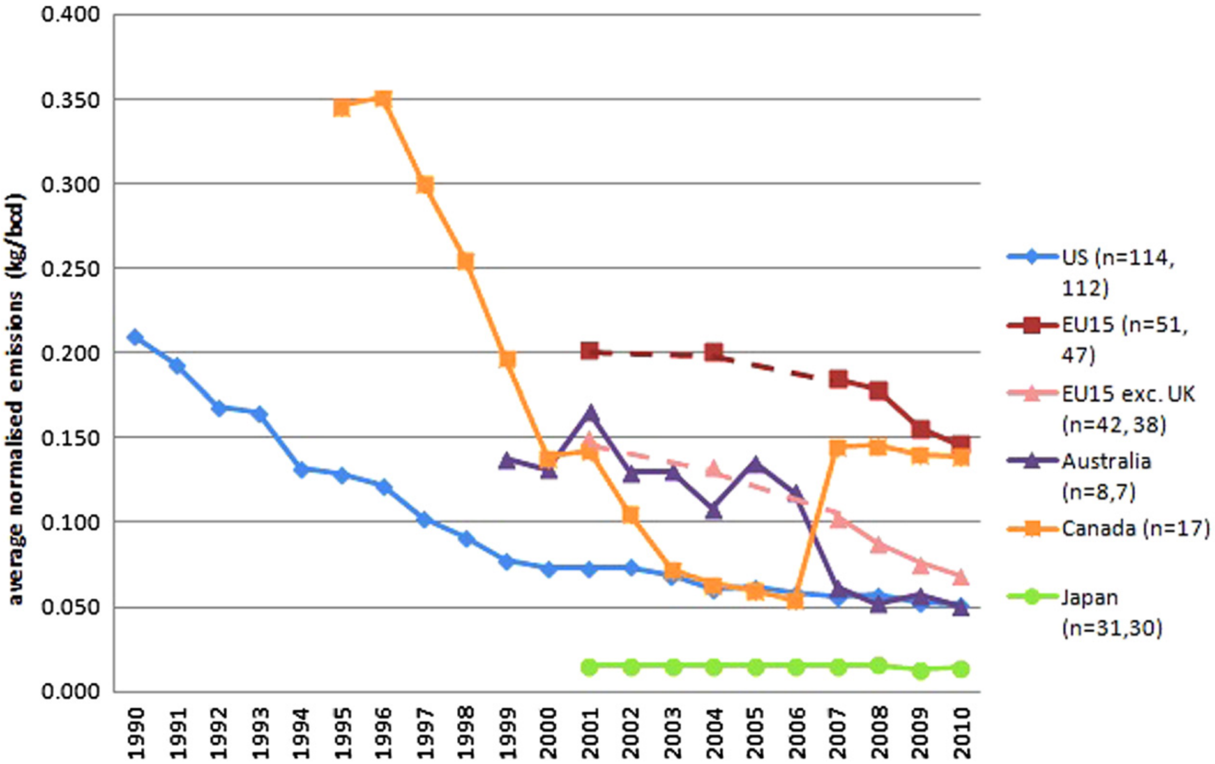

Figure 3. Comparison of normalized emissions for OECD Countries, 1990–2010 highlighting the effect of the United Kingdom on EU averages (see also figure 4.1 in supplementary material).

rhetoric does not match the reality—the outcomes of environmental regulation can be much lower in the EU than they are in other countries. Such an observation that the EU's rhetoric does not match the reality has been repeatedly made in the wider literature (cf Bretherton and Vogler 2006, Falkner 2007).

A final major and again closely related finding is that EU performance is particularly skewed by the exceptionally poor performance of the UK. Closer inspection of UK refinery performance reveals that in 2009/10 three of the nine refineries had normalized levels of performance that were close to the EU average, two emitted approximately 2 times the EU average, two emitted from 3 to 4 times the EU average and two emitted from 6.7 to 9.5 times the EU average (see figure 2). If we assume that there are no significant differences in levels of 'beyond compliance' behaviour in different countries, then this must mean that the minimum regulatory standards adopted for the majority of the refineries in the UK are substantially lower than those adopted elsewhere.

In seeking to understand the reasons why normalized emissions levels from UK refineries are higher on average (and especially in some instances) than in other EU countries, we conducted a small number of expert interviews with regulators, industry and pressure groups[2]. The responses of the different interviewees were quite consistent, with each respondent suggesting that the results could be the consequence of three interacting issues. The first is that there may be some older refineries in the UK that have not been upgraded for some time and that have a legacy of underinvestment in both process and pollution control technologies. The second is that regulators in the UK may have greater discretion in the way that they interpret and apply regulations, and that in exercising this discretion they may give greater emphasis to economic concerns than in other European contexts. The third is that given the first and second points, UK regulators may pay particular attention to ambient environmental quality standards when setting emissions limits, and only require substantial investment in upgrading industrial facilities if, for example, levels of benzene in local air quality exceed target levels as set out for example in the EU's air quality framework directive. Collectively, these issues could mean that higher emissions levels are permitted from refineries that are operating in contexts (i.e. on the coast where prevailing winds disperse emissions) where air quality limits are not exceeded, or at least where air quality monitoring does not regularly detect such breaches.

If we exclude the UK and run the data for the remaining EU member states we see a somewhat different picture, whereby the EU-15 is quite close to the emissions levels of the US and Australia (see figure 3). Such disparity among intra-EU emissions levels serves to further highlight a key problem in European environmental governance, namely that of ensuring that community policies are adequately translated into on-the-ground action (see e.g. Hunter and Smith 2005, Jordan and Tosun 2012, Leventon and Antypas 2012, Zhelyazkova 2013).

[2] Interviews were conducted with a former regulator with expertize in environmental risk and regulation, with an industrial environmental manager with expertize in better environmental regulation and with a pressure group lawyer with expertize in the interpretation and implementation of EU environmental law in the UK.

Apart from harmonization and implementation deficits on the EU level, the UK's laggardness with respect to reducing benzene emissions could reignite long-running debates on whether the UK could be viewed as the 'dirty man of Europe' (Rose 1991, Börzel 2002, Revell 2005).

5. Concluding remarks

As stated above, our findings are based on two key assumptions; first that PRTR data provides a sufficiently robust basis for a comparative analysis that compares emissions over time and between countries, and second that there is an observable link between regulatory standards and industrial performance. They are also based on a specific case that may or may not be more broadly representative. If we accept these assumptions and the value of the case, then the results could be significant in a number of ways. They suggest that there can be convergence in the environmental standards that are adopted and the levels of industrial performance that are realized in different countries over time, but that there are still instances where there are major variations in the outcomes of environmental regulation between OECD countries. They indicate that it is possible for countries to improve the outcomes of environmental regulation and to catch up with the best standards in the world, but they also reveal that it is still possible for some countries to adopt much lower standards than their major competitors. They suggest that it is possible for industry to gain a competitive disadvantage from being less heavily regulated, and for communities to be more heavily exposed to toxic emissions in some countries than in others. They reinforce claims that there is no guarantee that the EU's rhetoric about being a leader in international environmental policy is translated into practice, and that the outcomes of environmental policies within the EU can remain a long way from being harmonized. They also show that any claims that the UK might make that it is no longer the 'dirty man of Europe' are not always true.

More broadly, the paper demonstrates the value of comparative studies of the outcomes of environmental regulation across countries and over time. There is much debate on comparative standards in environmental regulation, but these debates are often characterized by a lack of evidence. Despite the potential for weaknesses in the data, we hope that this paper has demonstrated the value of such comparative analyses in generating such evidence and the need for further research with a similar approach.

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