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Pressure on the environment in European Union countries*

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Introduction

This short research note addresses a topic that has been neglected in the literature so far. The topic is whether and to what extent pressure on the environment in the 15 countries that currently form the European Union (EU) has decreased and, more interestingly, whether this pressure has converged among these countries. Convergence is defined here as a narrowing of the variation in the pressure among the relevant countries.

Why would one expect decreasing pressure on the environment in EU countries? The answer lies in a combination of policy and economics. On the policy side, increasingly stringent environmental regulations both at the national as well as at the Community level should lead to reduced pressure. To appreciate the changes in policies compare the situation in the early and mid-1980s, the starting point of the empirical evidence reported further below, with the one in the mid-1990s, the end period of this evidence. In the early 1980s, many of the countries that now form the EU, even the pioneering ones, had just begun to install the institutional framework in which environmental policies started to become developed (Andersen and Liefferink 1997; Hanf and Jansen 1998). On the Community level, the more comprehensive and ambitious Third, Fourth and particularly the Fifth Environmental Action Programme were still to come. In the mid-1990s, on the other hand, all countries were engaged in more comprehensive environmental policies based on an established institutional infrastructure and the Community was about to set up unprecedented progressive environmental provisions in the Treaty Establishing the European Community (Barnes and Barnes 1999; Krämer 1998; Neumayer 2001). On the economic side, secular technological improvements, rising resource productivity, as well as sectoral changes towards a less polluting service economy should have further reduced pressures. The economic and the policy side are inter-linked in many ways, of course. One important link is that it is often argued that higher income levels foster post-materialist attitudes among the population and strengthen preferences for environmental protection measures (Inglehart 1995). These developments, in turn, will put pressure on policy makers to enact strong environmental policies to counteract the increased pressure that rising levels of economic development would otherwise bring about.

Perhaps more interesting is the question why one would expect convergence in pressure on the environment among EU countries. To start with, one would expect such convergence because levels of economic development as well as primary energy use, the main drivers of pressure on the environment, in particular with respect to air pollution, have slightly converged as we will see later on. Second, the emergence of environmental regulation at the Community level should have had a converging effect on environmental pressure.[1] The tremendous change in the role environmental policy at the Community level plays is nicely summarised by Weale et al. (2000, p. 137) as follows: ‘In the space of two decades, environmental protection has developed within the EU from an unacknowledged and peripheral sector of public policy to one of the central components in the strategy for European integration.’ Third, the fundamental processes of economic internationalisation and globalisation together with the enhanced economic

[1] Of course, some of the currently 15 member countries joined the EU after the early 1980s, the beginning of our empirical assessment. However, after accession (and often even before) they had to take over Community legislation within a rather short period of time.

integration in the quest for a Single Market make the EU member countries' economies converge, which, all other things equal, should have a converging effect on pressure on the environment as well. On the other hand, bureaucratic and other inertia within countries can provide a powerful force maintaining divergence, given that most environmental measures need to be implemented and enforced by the individual member states.

For the reasons set out above, one might expect pressure on the environment to decrease over time and to converge in EU countries. Maybe somewhat surprisingly, however, convergence in pressure on the environment has, to the best of my knowledge, never been empirically assessed. What has been assessed and found evidence for is convergence of income levels and other quality of life indicators (see, for example, Giannia, Liargova and Manolas 1999) as well as convergence in environmental governance, that is in administration styles, instrument choice and policy formulation (Fernández 1994; Heritier 1995; Lenschow 1997; Weale et al. 1996, 2000). It is the objective of this research note to start filling this gap with respect to pressure on the environment.

I. Methodology

What is pressure on the environment? It stems from the emission of pollutants that have the potential to reduce the quantity and quality of environmental resources as well as harm human health. Of course, there are a great many different pressures and ideally one would want to address them all. Unfortunately, data availability does not allow this. Lack of data availability also means that we cannot address other potential environmental indicators such as ambient environmental quality indicators or ecological vulnerability indicators. In this article, we will therefore have to confine ourselves to a relatively small sample of emission output indicators for which time-series cross-sectional data are available:

- Sulphur oxides (SO_x), which damage human health and cause acid rain, which damages buildings, aquatic ecosystems and agriculture.
- Nitrogen oxides (NO_x), which contribute to the production of smog and acid rain.
- Volatile organic compounds (VOC), which play an important role in the production of photochemical oxidants.
- Carbon monoxide (CO), which decreases the absorption of oxygen by red blood cells.
- Carbon dioxide (CO_2), which is the major greenhouse gas causing global warming.
- Organic water pollutants, measured as biochemical oxygen demand, referring to the amount of oxygen that bacteria in water will consume in breaking down waste. Organic water pollutants are a major cause for water quality degradation.
- Consumption of fertilisers, which can have negative effects on the quality of water, including drinking water.
- Consumption of pesticides, which can damage wildlife and human health.

As can be seen, most of the pressures looked at here cause air and water pollution. They are also the environmental problem areas that were targeted by most EU countries early on before other areas such as soil protection and chemicals regulation became tackled (Weale et al. 2000, p. 141). This is fortunate as convergence, if existent, should be most clearly visible in areas tackled early on.

How can one compare pressure on the environment in different countries given that population size and the size of the economy differ quite dramatically? We will use two different ways here to make pressure comparable: we will look at pressure per capita as well as pressure per unit of gross domestic product (GDP). In assessing whether pressure has decreased over time, we will look at the simple average of pressure among EU countries. We will not look at an average weighted by population or economy size since we are interested in how pressure in inter-country comparison has developed rather than in how “representative” pressure within the EU has developed.

In assessing whether there has been convergence in pressure, we look at the so-called coefficient of variation (COV). This coefficient is defined as

$$COV = \frac{\frac{1}{N}\sqrt{\sum_{i=1}^{N}(X_i - \overline{X})^2}}{\overline{X}}$$

where N is the number of countries, X_i is the relevant data entry of country i for pressure X, and $\overline{X}$ is its arithmetic mean. Note that the numerator is nothing else but the standard deviation. In some cases limited data availability means that N is below 15, the current number of EU member countries.

Note that the COV is independent of the unit of measurement used and “normalised” in dividing the standard deviation by the mean. It can therefore be used to compare the variability of data measured in the same unit, but with different means, as well as data measured in different units. It is often expressed in percentage terms, where 0% would imply no variability.

To reduce data gaps, we use three year averages, which ideally is the simple average of the data from the relevant three years. However, if data was only available for two out of the three years, then their average was taken. If data was available for one year only, then that year's data was taken for the whole three year period. While this method introduces some bias into the results, there is no reason to presume that it would have any systematic impact upon our questions of concern here. For some indicators, data were available from 1980 onwards to 1997. However, for most indicators the covered period is 1985 to 1996. Most data on environmental indicators stem from OECD (1999), with the exception of carbon dioxide emissions, which are taken from Marland, Boden and Andres (2000), primary energy use data, taken from British Petroleum (1993, 2000), and organic water pollution, taken from World Bank (2000). Data on population size as well as (real) GDP per capita in purchasing power parity are also taken from World Bank (2000).

II. Results

Table 1 shows time trends in the COV as well as the mean for real GDP per capita as well as primary energy use, measured on a per capita as well as per unit of GDP basis. Note that in the case of GDP per capita *N* is equal to 14 as Luxembourg has been taken out. This small country, more a wealthy city than a country compared to the rest of member countries, represents a strong outlier in the sense that it has had extra-ordinary growth in income levels despite an already high initial income level. If Luxembourg is included then there is little convergence apparent, but given its size and its particular characteristics, its inclusion would mask the fact of convergence in level of economic development within the EU.

< INSERT TABLE 1 ABOUT HERE >

Looking at the COV and the mean of GDP per capita we see both a dramatic increase in average income levels as well as convergence, which can be seen by the decrease in the COV over time. In both senses, the EU really represents a success story, where its member countries have achieved ‘the strengthening and convergence of their economies’ as currently proclaimed in the Preamble to the Treaty on European Union.

Table 1 also shows that primary energy use per unit of GDP has slightly decreased and converged among EU countries.[2] This decrease in energy intensity of GDP has not been enough to decrease levels of primary energy use per capita, however, which has constantly increased due to strong economic growth, that is increases in GDP. Convergence is slightly more pronounced if primary energy use is measured on a per capita basis. As the level of economic development and primary energy use are important drivers of pressure on the environment, all other things equal one would expect some convergence in pressure as well.

Turning to indicators of pressure on the environment we see an altogether different picture, however, as far as convergence is concerned.[3] Table 2 shows time trends in the COV as well as the mean for emissions of sulphur oxides (SO_x),

[2] Note that *N* is equal to 14 as the source provides primary energy data for Belgium and Luxembourg taken together.

nitrogen oxides (NO_x), volatile organic compounds (VOC), carbon monoxide (CO), carbon dioxide (CO_2), organic water pollutants as well as consumption of pesticides and fertilisers, all on a per capita basis. While mean pressure has decreased throughout (or stagnated in the case of CO_2), there is very little convergence in pressure apparent. In some cases such as SO_x emissions and fertiliser consumption, we actually observe divergence!

< INSERT TABLE 2 ABOUT HERE >

Another interesting observation is that the variation in pressure on the environment is above the variation in GDP as well as, for some pressures at least, above the variation in primary energy use. This can be seen by the fact that the COV for all pressure indicators is higher than the COV of GDP and is suggestive of substantial cross-country differences in the strictness of the regulation of these pressures.

The same basic picture holds true if we look at these indicators in terms of per unit of GDP rather than per capita (see table 3).[4] Note that this table does not show pesticide and fertiliser consumption per unit of GDP as these would not make much sense as indicators of pressure on the environment. Also note that CO emissions and CO_2 emissions appear twice, once in the full sample, the other time in a sample where Luxembourg has been excluded. This is because of the special influence of Luxembourg on GDP based measures already noted above. For all

[3] Note that the covered time period differs for two indicators from the rest due to better data availability.

other indicators the exclusion of Luxembourg does not make much difference so that merely the full sample case is reported.

< INSERT TABLE 3 ABOUT HERE >

Looking at table 3, we see that throughout mean pressure is decreasing with little convergence apparent and divergence emerges again in the case of SO_x emissions and fertiliser consumption. The only exception is CO_2 emissions, which show a clear converging trend if measured per unit of GDP in the full sample case, but not if Luxembourg becomes excluded.

III. Discussion

How can the non-convergence in pressure on the environment be explained? To start with, the explanation does not lie in the sometimes dubious quality of the environmental statistics. To be sure, the quality of environmental statistics is often relatively poor in comparison to other statistics. Most of them come with a qualification to the effect that 'the definitions of sources as well as the measurement methods may vary from country to country' (OECD 1999, p. 20) and that the data need to be treated with caution. However, there is no reason to presume that the imprecision apparent in the data has any systematic influence on the existence or not of a converging trend.[5]

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[4] The reader should note that from an environmental and human health perspective, pressure per capita is the more relevant indicator, of course.

[5] One anonymous reviewer wondered whether the results are partially triggered by the distorting effect German reunification and partial de-industrialisation of the East German Länder might have

One plausible explanation could be that the existing national regulations of pressure on the environment have not converged much and that the converging effect of Community induced environmental measures has been rather small, at least so far. Most studies on convergence in environmental governance find only modest evidence for some limited convergence, keeping in mind of course that these studies often look more at the style of environmental policy making rather than the strictness of emission standards (see Fernández 1994; Heritier 1995; Lenschow 1997; Weale et al. 2000). Since European policies are dependent on their implementation through national administrations the persistent divergence with respect to environmental governance will lead to divergent environmental policy outcomes as well (Knill 1997; Knill and Lenschow 1997; McCormick 2001). Interestingly, Jordan (1999) argues that implementation deficits are hard to overcome since in part those deficits are necessary to maintain a delicate balance between supranational and national regulation authority.

Furthermore, it might be too early still for Community induced environmental measures to have a strong converging effect, even though it has been hailed as standing out 'as a notable European and international policy achievement when compared to other EU issue areas' (Zito 2000, p. 2). As Weale et al. (2000, p. 186) put it: '…the new dynamism of EU environmental policy from the mid-1980s only really began to have some qualitative impact on national policies from the early 1990s, especially in southern Europe'. For example, regulation of VOC was adopted at the EU level not before 1994. It is likely to take even longer until these changes in policies translate into changes in pressure on the environment.

on the results reported. In sensitivity analysis I took out Germany from all computations. None of the results were substantially affected.

Maybe, therefore, if one were to repeat this article's exercise in ten years time or so, one might find much stronger evidence for convergence starting in the mid-1990s. Note, however, that even in the case of NO_x and SO_x emissions, which have been subject to EU wide regulation for a considerable period of time, there are few signs for convergence and indeed some indication of divergence in the case of SO_x emissions. The latter might be explained by the fact that regulation is incomplete and that Greece, Ireland and Portugal were allowed to increase their emissions at the same time as other countries had to cut back their emissions (Weale et al. 2000, p. 387). More generally, the willingness of environmental 'leaders' to accept to some extent divergent policy outcomes in 'laggard' countries might partly explain why in many cases environmental pressure in EU countries is improving on average, but is not converging.

IV. Concluding remarks

Given the economic and policy changes in EU countries during the period of our study one would expect pressure on the environment to have decreased and converged. In looking at pressure related to air and water pollution we observe decreased pressure, but there is very little evidence for and sometimes even evidence against convergence. This represents somewhat of a puzzle. Two aspects of this puzzle need to be explored in future research. First, does the puzzle hold in other areas of pressure on the environment as well? Due to limited data availability, this analysis concentrated on pressure that mainly causes air and water pollution. There is no reason to presume that other areas should show stronger signs of convergence, but one cannot be sure. As data become available for other areas as well, a similar analysis needs to be repeated. Second, what factors can explain non-convergence? One possible answer is that the factors going against convergence such as bureaucratic inertia coupled with national idiosyncracies in environmental policy making prevent convergence. Another possibility is that it is too early still to detect convergence and that the factors causing convergence need a longer time span to have a significant impact upon pressure on the environment. But no more than these rather tentative answers are given here as this really represents a topic for future research. All in all, therefore, this research note has posed as many new questions as it has given answers, but it is hoped that these questions are worth further exploration.

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Table 1. GDP and primary energy use.

Time period	**Real GDP p.c. (N=14) (in constant 1992 US$)**		**Primary energy use per GDP (N=14) (in tonnes of oil equivalent per 1000US$)**		**Primary energy use per capita (N=14) (in tonnes of oil equivalent)**	
	COV	$\overline{X}$	COV	$\overline{X}$	COV	$\overline{X}$
1980-82	0.06	14007.08	0.07	0.22	0.10	3.08
1983-85	0.06	13435.72	0.07	0.23	0.10	3.14
1986-88	0.05	15893.79	0.07	0.21	0.10	3.36
1989-91	0.05	16617.76	0.06	0.21	0.09	3.50
1992-94	0.04	16998.88	0.06	0.21	0.08	3.57
1995-97	0.04	18269.99	0.06	0.20	0.08	3.74

Table 2: Pressure on the environment per capita.

	SO_x emissions in kg (N=15)		**NO_x emissions in kg (N=14)**		**VOC emissions in kg (N=14)**	
Time period	COV	$\overline{X}$	COV	$\overline{X}$	COV	$\overline{X}$
1985-87	0.11	42.27	0.08	40.14		
1988-90	0.12	35.99	0.08	41.20	0.08	43.74
1991-93	0.12	35.39	0.07	41.07	0.06	42.06
1994-96	0.13	28.29	0.07	37.01	0.06	38.00

	CO emissions in kg (N=14)		**Pesticide consumpt. in kg (N=12)**		**Fertiliser consumpt. in kg (N=14)**	
Time period	COV	$\overline{X}$	COV	$\overline{X}$	COV	$\overline{X}$
1985-87			0.23	1.03	0.17	69.73
1988-90	0.15	157.17	0.25	1.04	0.18	67.99
1991-93	0.20	159.42	0.25	0.90	0.19	60.17
1994-96	0.12	126.08	0.25	0.85	0.21	58.72

	CO_2 emissions in metric tonnes of carbon (N=15)		**Organic water pollutants in g per day (N=14)**	
Time period	COV	$\overline{X}$	COV	$\overline{X}$
1980-82	0.14	2.56	0.09	13.27
1983-85	0.13	2.36	0.09	12.27
1986-88	0.13	2.41	0.09	11.75
1989-91	0.14	2.54	0.08	11.80
1992-94	0.14	2.54	0.08	11.13
1995-97	0.10	2.48		

Table 3. Environmental pressure per 1000 $ of GDP (constant 1992 US$).

Time period	**SO_x emissions in kg (N=15)** COV	$\overline{X}$	**NO_x emissions in kg (N=14)** COV	$\overline{X}$	**VOC emissions in kg (N=14)** COV	$\overline{X}$
1985-87	0.13	3.27	0.07	2.87		
1988-90	0.15	2.75	0.07	2.81	0.08	3.11
1991-93	0.16	2.31	0.06	2.39	0.09	2.61
1994-96	0.18	1.85	0.07	2.15	0.07	2.32

Time period	**CO emissions in kg (N=14)** COV	$\overline{X}$	**CO emissions in kg (N=13) (LUX excluded)** COV	$\overline{X}$
1985-87				
1988-90	0.10	10.81	0.06	9.84
1991-93	0.13	9.22	0.08	8.13
1994-96	0.09	7.46	0.08	7.11

Time period	**CO_2 emissions in metric tonnes of carbon (N=15)** COV	$\overline{X}$	**CO_2 emissions in tonnes (N=14) (LUX excluded)** COV	$\overline{X}$	**Organic water pollutants in g per day (N=14)** COV	$\overline{X}$
1980-82	0.11	0.18	0.06	0.16	0.08	0.97
1983-85	0.10	0.17	0.06	0.15	0.07	0.92
1986-88	0.10	0.15	0.08	0.14	0.07	0.73
1989-91	0.09	0.14	0.07	0.13	0.07	0.69
1992-94	0.08	0.14	0.06	0.13	0.08	0.65
1995-97	0.06	0.13	0.06	0.12		