EU Polluting Emissions: An empirical analysis

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Abstract

We provide an empirical study of the evolution of emissions of some specific air pollutants on a panel of EU member states from 1990 to 2000, and we relate observed patterns to macroeconomic performance. The ratio pollution emission to GDP, so-called emission intensity, has decreased over the period considered in most EU member states. However, a non-parametric analysis reveals that the relative positions of different countries in terms of GDP growth and reduction of emissions have remained basically unchanged. More specifically, remarkable differences can be detected between the richest and the poorest EU members notwithstanding. Also, more dispersion in emissions levels can be found in those countries with lower per capita GDP.

1 Introduction

European Union (EU) interest on environmental issues has grown largely in the last two decades, as the numerous initiatives involving directly Member States show. EU action goes principally towards two directions:

- Setting emissions reductions targets on pollutants responsible for the "Global Warming Effect", according to the international commitment resumed in the Kyoto Protocol;

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- Regulating, on an internal base, emissions of ozone precursors from specific sectors, mainly "industry" and "road transport".

The motivation of this work arises above all from the relevance of EU air pollution internal regulation, that represents the largest part of all environmental measures defined and adopted by the Union. This regulation aims principally to reduce polluting emissions from industry, energy and road transport. The economic consequences of these actions are of extreme importance since the main attention is focused on the most important by-products of motor vehicles circulation, many industrial activities and most part of energy use.

The most "Trans-National" way by which pollution affects the environment is represented by emissions through the "air". As a matter of fact, scientists during the 1960s demonstrated the existence of a connection between sulphur emissions in continental Europe and the acidification of Scandinavian lakes.[1] This means that atmospheric pollutants can travel, thanks to the wind, several thousands kilometers before deposition and damage occur. Therefore, *Transboundary Pollution*, as it is defined, is directly related to phenomenons such as acidification and eutrophication mainly provoked by anthropogenic emissions of Nitrogen Oxides (NO_x), especially Nitrogen Dioxide (NO_2), Sulphur Dioxide (SO_2) and Ammonia (NH_3). Anthropogenic NO_x are mainly contained in the exhaust emissions of diesel and petrol powered "on" and "off-road" engines; exhaust emissions come from the incomplete fuel combustion during engine operation. Such incomplete combustion occurs mainly in the operation of "on-road" engines (motor vehicles), even if a consistent proportion comes from "off-road" engines, as it is the case of com-

[1] "Acidification" is the change in the natural chemical balance of an environment, caused by an increased concentration of acid elements. Alternatively, "eutrophication" is the excessive enrichment of an ecosystem with nutrients that determines lots of adverse biological effects.

bustion for energy production. SO_2 emissions come mainly from the combustion of poor-quality coal and petroleum in energy production activities and partly from that of sulphur-containing fuels (diesel) in motor vehicles. NH_3 emissions are directly related to the use of fertilizers in agriculture. The deposition of these pollutants causes the loss of fisheries in water, the impoverishment of the soil and dangerous effects on vegetation. In particular, the action of nitrogen containing compounds favors both terrestrial and marine eutrophication.

Together with their transboundary effects, some of these pollutants have other dangerous consequences when persisting into the air, no matter if they travel lots of kilometers or not. NO_x, for instance, react in the presence of solar radiation with other chemical compounds to form *Tropospheric (or Ground-Level) Ozone*[2], a highly corrosive and poisonous substance representing the key ingredient of urban smog. As a consequence, NO_x are also defined "Ozone Precursors" a category of pollutants that includes gases like Carbon Monoxide (CO) and Non-Methane Volatile Organic Compounds ($NMVOC$). Anthropogenic CO is chiefly contained in the petrol and diesel powered vehicles exhaust[3] and contribute by the largest part to the formation of the smog. $NMVOC$ emissions come largely from the evaporation that occurs for the use of solvents in certain industrial processes and at a smaller scale from exhaust of motor vehicles.

[2] Ozone exists in two layers of the atmosphere, the stratosphere and the troposphere. The last one corresponds to that near Earth surface or, better said, it corresponds to the air we breathe. Here ozone presence is dangerous for both health and environment

[3] CO production is a direct function of the air/fuel ratio in the engine. When air supply is restricted, for instance during vehicle starting or at altitude where "thin" air reduces oxygen available for combustion, the incomplete fuel combustion is higher and so is CO generation.

EU measures on emissions from road transport represent the main part of the entire internal regulation and the one with the longer tradition, their antecedents back through 1970. They consist in a body of directives mandatory for all member states. This legislation basically fixes limit values to the CO and NMVOCs emissions from light and heavy road commercial vehicles as special technical requirements needed by such vehicles to get the "type-approval" and so being available for sale and circulation. During the nineties, the EU started to integrate this road transport legislation by the implementation of the Auto-Oil Program that includes the commitment in the development of studies on fuel quality of petrol and diesel and on alternative fuels in the transport sector and the commitment in signing agreements with the automobile industry. There exists another body of directives, smaller than the one on road transport, that covers emissions from a variety of industrial activities. This legislation, starting by the end of the eighties, is drawn up by kind of industrial activity and basically fixes emissions ceilings for specific pollutants, at the same time it establishes specific and mandatory environmental requirements necessary to the interested industrial installations in order to go on working.

Together with the legislative activity aimed at the reduction of ozone precursors inside Europe, the EU works also at international level to reach the same objective, as reflected by the signature of the Convention on Long Range Transboundary Air Pollution (CLRTAP) in 1979, the first legally binding instrument to deal with problems of air pollution on a broad regional basis. This convention has been extended by eight protocols, the first of which was approved under the United Nations Economic Commission for Europe (UNECE) in 1984, by EU members, the rest of European countries and the United States, with the scope of financing on a long-term basis the so called "European Monitoring and Evaluation Program" (EMEP). EMEP is a program for monitoring and evaluation of long range transmission of air pollutants in Europe under which, it has been drawn up an Emission Inventory Guidebook that explains the methodology to collect emissions data. This guidebook is especially directed to participant countries, that have to send annually emissions data to the interested international organisms devoted to process them. One of this organism is the European Environment Agency (EEA), established by a Community Regulation in 1990 and operational since 1994. The EEA aims to support sustainable development and to help achieve significant and measurable improvement in Europe's environment through the provision of targeted and reliable information to policy-making agents and the public. The Agency processes emissions data from European countries to knowledge at European level, according to the EMEP methodology and cooperates with international partners to gather, process and distribute data and information. Ad so, thanks to the EMEP and EEA task, it is publicly available an official dataset on emissions of CO, $NMVOCs$, SO_2, NO_x and CO_2 from almost all European countries. Given the emphasis EMEP methodology put on the accuracy of data collection (as shown in the cited guidebook) and its continuous updating, we base our study on this dataset. As it is shown in this article in a descriptive way, in most of EU Member States emissions of CO, $NMVOCs$, SO_2 and NO_x seem to decrease during the nineties.

Insert table N. 1

Actually, it would be interesting to detect an impact of EU legislation on emission trends of CO, $NMVOC$, CO_2, SO_2 and NO_x; however we can work only with a short sample (ten years) as Section 2 illustrates and this can limit the analysis.

Once examined trends during the nineties, we consider the cross sections of the beginning and the end of the period considered and compare them in order to verify if there has been a significant emissions reduction and eventually a significant change in the relative positions of countries. To do this we employ a non-parametric approach; according to the statistical results, emissions have decreased but relative positions have not changed significantly.

Finally, we try to take into account the emissions performance and the economic development of the previous cross sections, employing emissions and GDP per capita, in order to explore the association between these two features. We would like to identify which countries exhibit a positive growth and reduce polluting emissions at the same time and which countries do not.

The rest of the paper is organized as follows. Section 2 describes the data and define the measures employed. Section 3 illustrates the evolution of emissions during the nineties, by groups of countries. Section 4 goes through the details of the cross section analysis. Finally, section 5 resumes the main conclusions.

2 Data and Definitions

Data on pollutants, *CO, NMVOCs,* CO_2*,* SO_2 *and* NO_x (expressed in kilotonnes) are available at http://themes.eea.eu.int/Specificmedia/air/data. The dataset covers all EU members and almost all new members. However, to work with a balanced sample, we use data from the following countries: Austria (AT), Belgium (BE), Denmark (DK), Finland (FI), France (FR), Germany (DE), Great Britain (GB), Italy (IT), Netherlands (NL), Sweden (SE), Greece (GR), Ireland (IE), Portugal (PT), Spain (ES), Czech Rep. (CZ), Hungary (HU), Latvia (LV), Slovak Rep. (SK), Slovene Rep. (SL) and Poland *(POL).*

Data on real chained per capita Gross Domestic Product (GDP) and Population are taken from the Penn World Table (PWT), available at http://pwt.econ.upenn.edu/aboutpwt.html. GDP is measured in international thousand dollars and Population in thousands people.

All data have annual frequency. The sample period considered is 1990-2000. Additionally, we define the "emission intensity" as the ratio of emission over real GDP for each of the pollutant considered.

3 Time series evidence

According to what we have found out through emission intensity time series examination, we group countries as follows:

- Group 1: FR, DE, GB, IT;
- Group 2: AT, BE, DK, FI, NL and SE;
- Group 3: GR, IE, PT and ES;
- Group 4: CZ, HU, LV, POL, SK and SL.

In particular about group 4, we decide to put together all new members. All these countries have already signed the treaty of accession (16 April 2003) that *entered* into force on 1 May 2004.

We explore emission intensities for all pollutants in each group in order to give a picture of countries performance. In what follows we explore intensity performances by group.

Group 1 countries exhibit decreasing trends as Figs. 1, 5. 9 and 13 illustrate. DE shows the best performance in *all* pollutants. Actually, its intensities level decrease faster than that of the rest of the group, indicating that while GDP is growing, emissions are decreasing over time. Moreover, DE intensities are the lowest during all the period. The worst performance is represented by IT, that displays the lowest reduction in all pollutants. Actually, IT trends are clearly decreasing only from 1995. Finally, the distance among countries levels is higher in the case of CO and SO_2.

Group 2 countries exhibit some differences among the pollutants. As a matter of fact, Figs. 2, 6, 10 and 14 show that CO intensities are evidently decreasing in the case of AT and NL, while for the rest of the group they display a quite homogeneous and stable pattern. NL performance is obviously the best one, replicating DE features. Moreover, while NL has the lowest value, AT has the highest one and the other four countries show fairly the same levels, during all the period. For the rest of the pollutants, decreasing intensities are those of NL while the rest of the group exhibits more or less stable trajectories. Looking at levels, we see that BE, DK and NL are the members that are between the group.

Group 3 countries display very similar trends in the pollutants. All trends do not seem to indicate good emission performances. GR and PT intensities are slightly increasing over the period in all pollutants, while ES seems to decrease a bit only from 1995 in SO_2 and NO_x. Special mention goes to the case of IE intensities that decrease quite evidently over time; however it is important to highlight the strong increase in GDP experimented by this country during the second half of the nineties. This special circumstance maybe explains IE apparently good performance through time.

Group 4 countries, the group of the newer entrants, is probably the most heterogeneous one in both pollutants, as it is illustrated by Figs. N. Figs. N.4, 8, 12 and 16. In the case of CO, Fig. N.12, the best performers seem SK and CZ because intensities are clearly decreasing from 1993. SL has the lowest level but its trend seems slightly increasing. The other two countries, HU and TR, display stable trends. LV, *in the case of* CO *and* $NMVOC$Figs. N. 12 and 16, show the highest level and the most irregular trajectory over time. In the case of NMVOCs, Fig. N.2d, the only country that clearly shows a decreasing intensity is CZ. TR exhibits an increasing trend from 1994, SK has an extremely irregular behaviour, while HU and SL seem quite similar and stable along time. LV, Fig. N.3b, behaves irregularly as in the case of CO and with respect to the other countries of group 4, has the highest levels during almost all the period.

4 Cross-section analysis

According to what is found out in Section 3, it seems that some countries have decreased their polluting emissions and consequently, by the end of the sample period considered, emissions levels and countries relative positions could be different with respect to those of the beginning of the period. In this section we try to investigate if there have been significant changes in emission intensities between 1990 and 2000 and to do this we employ the two corresponding cross sections. More precisely, we give a statistical measure of such changes using non-parametric statistics. We start the analysis considering a reduced sample including only EU former members (groups 1-3) and we try to answer three basic questions:

1. Have the countries reduced polluting intensities from 1990 to 2000?
2. Have the countries changed their relative position in the emission intensity ranking from 1990 to 2000?
3. Have distances between countries changed form 1990 to 2000?

To this end we run some tests on homogeneity between samples and independence between samples characteristics. These tests are respectively the Kolmogorov-Smirnov and Wilcoxon tests (question 1, above), Spearman and t-Kendall tests (question 2) and finally the Siegel-Tuckey test (question 3); the samples whose characteristics have to be checked, are the 1990 and 2000 sets of emission intensities from EU members. The tables with the corresponding statistics are presented at the end of the paper. The main findings are summarized as follows.

The relevant result about question 1 is that emissions intensities for CO, $NMVOC$, NO_x and SO_2 have decreased in 2000 with respect to 1990. With respect to CO_2 we find that the statistical result in not significative: emissions have not decreased for this pollutant. This is not surprising, given that concern in this area is relatively more recent. About question 2 and 3, all tests indicate that relative positions and distances among countries have not changed from 1990 to 2000 with regard to emission intensity. Nevertheless, as seen in time series evidence, countries like DE or IE have moved a lot during the sample period; furthermore, we have the intuition that the force determining IE performance is different from that at the base of the DE one. In fact, we know that IE has experienced a large increase in its GDP level during the nineties and it could be useful to separate this effect from the emissions levels performance.

We made an effort to detect changes between sectors, including energy, industry and transport. At the end of the paper we include tables with the statistical findings. In general, we find different patterns between pollutants depending on the main source: industry, energy and transport.

For EU20 with respect to the energy sector we find that emissions have decreased only for SO_2 and NO_x, but positions among countries have not changed significantly, according to Spearman and τ-Kendall. On the other hand, with respect to industry SO_2 and CO seem to have decreased. For all the pollutants, no changes in positions have appeared. Finally, for transport, all the pollutants have decreased its emissions, except NO_x while there are no changes in the positions between countries during the period.

To illustrate this kind of differences among the considered countries, that is taking into account economic size from one side and emissions level from the other, we graph the 1990 and 2000 scatters of GDP per capita versus polluting emissions per capita of all countries, for both pollutants, Fig. N.17-24. In this context, we interpret as a relatively "efficient (or good) performance", that of a country experiencing a positive growth of its GDP and a negative growth of its polluting emissions; in terms of the scatters, comparing 2000 to 1990 plots, we should be able to verify if countries have moved to the right and downwards. It is clear that there exists two main groups of countries according to GDP per capita levels. In 1990 the group of the richest countries (looking at the horizontal axis, countries to the right of zero), shows a little bit more dispersion in the case of CO per capita than in that of NMVOCs. Countries relative positions and distances between countries inside this group are not the same in both pollutants. For instance, in the CO scatter, AT and SE are quite far from each other, while in the NMVOCs one, the opposite is true; we can say the same for DE and NL and so on.

The other group of countries (the "poorest" one, to the left of zero, on the horizontal axis), exhibits more dispersion than the previous one, both from emissions (there is no appreciable difference between CO and NMVOCs) and GDP per capita point of view. Relative positions inside this group do not seem very different when we look at CO and NMVOCs scatters. We notice that this greater dispersion is above all due to some of the new members, like CZ, LV and HU.

Looking now at the 2000 plots to be compared with 1990 ones, we observe that the richest group, in both pollutants, has clearly moved to the right and downwards, reducing its dispersion. In other words, it has experimented a positive growth in GDP per capita and a negative growth in CO and NMVOCs per capita. Apart from the big jump downwards of DE inside the group, as reflected by gross growth rates in Table N.2, relative positions do not seem to have changed a lot.

The case of the other group is a bit more difficult to analyze, both in CO and NMVOCs. Scatters reveal again more dispersion than that of the rich group; furthermore, on both axis and in both pollutants, we cannot appreciate a clear shift of the group as a whole. Some countries experiment a reduction of GDP per capita, such as CZ, SK, HU and LV, over the entire period, and a reduction of emissions, (see Table N.5). Among the others, all with positive growth of GDP per capita, IE represents a special case, as already mentioned, seeing its big shift to the right, comparing 1998 with 1990 plots. However, IE does not experiment a proportional reduction in polluting emissions. Another peculiar case is the one of CZ that shows a positive growth of its GDP per capita and, at the same time, a positive growth in NMVOCs per capita emissions; as Table N.5 illustrates, the 1990-2000 rate of growth of NMVOCs exceeds largely that of GDP.

5 Conclusions

The main results of this study can be summarized as follows. Intensities trends of most of the considered countries are decreasing over the sample period; however, the statistical results of the non-parametric tests suggest that the reductions are not very large among EU members and that relative positions and distances among them have not changed. In any case, it has to be highlighted the performance of DE and NL: their intensities for both pollutants are clearly decreasing and show the highest 1990-1998 rates of growth. When separating the economic size aspect from the emissions level one, we distinguish two main groups by GDP per capita level; the richest one moves to the right and downwards in 2000 with respect to 1990, as the scatters in both CO and NMVOCs per capita show, while for the poorest one we cannot see a clear shift of the group as a whole. The only remarkable and evident feature is that this last group is more dispersed than the other one, in both pollutants.

6 Appendix

Table N. Growth rates 1990-2000 (%) per group- Variables in per capita values.

	SO_2	NO_x	$NMVOC$	CO	CO_2	GDPpc
EU15	-44.04	-8.19	-18.6	-28.58	2.43	23
New EU	-76.56	-45.03	-42.84	-46.71	-41.11	1.96
Total	-58.35	-17.63	-23.85	-33.43	-11.11	19.77

Table N. Growth rates 1990-2000 (%) per sector- Variables in per capita values.

	SO_2	NO_x	$NMVOC$	CO	CO_2
Energy	-47.35	-27.56	56.24	28.06	-36.3
Industry	-50.14	-12.51	-3.53	-29.07	-4.52
Transport	-46.28	-0.83	-31.57	-33.47	10.98

Table N. Non-parametric tests by pollutant. EU20

	SO_2	NO_x	$NMVOC$	CO	CO_2	$GDPpc$
			Spearman			
Correlation	.678	.277	.462	.558	.936	.830
t statistic	3.915	1.222	2.208	2.852	10.323	6.131
Significance value	.001	.238	.040	.011	.000	.000
n	20	20	20	20	17	19
			$\tau - Kendall$			
Correlation	.526	.211	.358	.411	.824	.684
t statistic	4.583	1.145	2.143	2.434	10.958	5.419
Significance value	.000	.252	.032	.015	.000	.000
n	20	20	20	20	17	19
			Wilcoxon			
Statistic	-3.920	-3.211	-3.397	-3.733	-.876	-3.662
Significance value	.000	.000	.001	.000	.381	.000
Positive ranks	0	3	2	1	7	18
Negative ranks	20	17	18	19	10	1
Total	20	20	20	20	17	19

Table N. Non-parametric tests by sector: energy. EU20

	SO_2	NO_x	$NMVOC$	CO	CO_2
			Spearman		
Correlation	.632	.618	.515	.846	.777
t statistic	2.941	2.833	2.246	5.731	4.780
Significance value	.011	.014	.041	.000	.000
n	15	15	16	15	17
			$\tau - Kendall$		
Correlation	.486	.429	.467	.657	.618
t statistic	3.550	2.372	2.099	6.567	4.987
Significance value	.000	.018	.036	.000	.000
n	15	15	16	15	17
			Wilcoxon		
Statistic	-3.010	-2.556	-.259	-1.477	-.335
Significance value	.003	.011	.796	.140	.723
Positive ranks	1	3	8	4	8
Negative ranks	14	12	8	11	9
Total	15	15	16	15	17

Non parametric tests by sector: industry. EU20

	SO_2	NO_x	$NMVOC$	CO	CO_2
			Spearman		
Correlation	.824	.723	.726	.879	.665
t statistic	5.041	3.626	3.955	6.632	3.329
Significance value	.000	.003	.001	.000	.005
n	14	14	16	15	16
			$\tau - Kendall$		
Correlation	.648	.604	.667	.790	.567
t statistic	5.311	3.400	3.746	6.275	2.971
Significance value	.000	.001	.000	.000	.003
n	14	14	16	15	16
			Wilcoxon		
Statistic	-2.982	-1.224	0.000	-2.669	-.362
Significance value	.003	.221	1.000	.008	.717
Positive ranks	4	6	8	4	10
Negative ranks	12	8	8	11	6
Total	14	14	16	15	16

Non parametric tests by sector: transport

	SO_2	NO_x	$NMVOC$	CO	CO_2
			Spearman		
Correlation	.821	.589	.475	.756	.691
t statistic	5.193	2.630	2.093	4.320	3.704
Significance value	.000	.021	.054	.001	.002
n	15	15	17	16	17
			$\tau - Kendall$		
Correlation	.676	.410	.397	.667	.529
t statistic	6.006	2.091	2.032	4.041	3.416
Significance value	.000	.037	.042	.000	.001
n	15	15	17	16	17
			Wilcoxon		
Statistic	-3.408	-1.817	-2.107	-2.068	-2.533
Significance value	.001	.069	.035	.039	.011
Positive ranks	0	4	5	5	13
Negative ranks	15	11	12	11	4
Total	15	15	17	16	17

Table N. Summary of non-parametric tests

	SO_2	NO_x	$NMVOC$	CO	CO_2
Have EU members reduced their polluting emissions from 1990 to 2000?					
EU20	Yes	Yes	Yes	Yes	No
Energy	Yes	Yes	No	No	No
Industry	Yes	No	?	Yes	No
Transport	Yes	No	Yes	Yes	Yes
Have EU members changed their relative position in the emissions ranking from 1990 to 2000?					
EU20	No	Yes	No	No	No
Energy	No	No	No	No	No
Industry	No	No	No	No	No
Transport	No	No	No	No	No

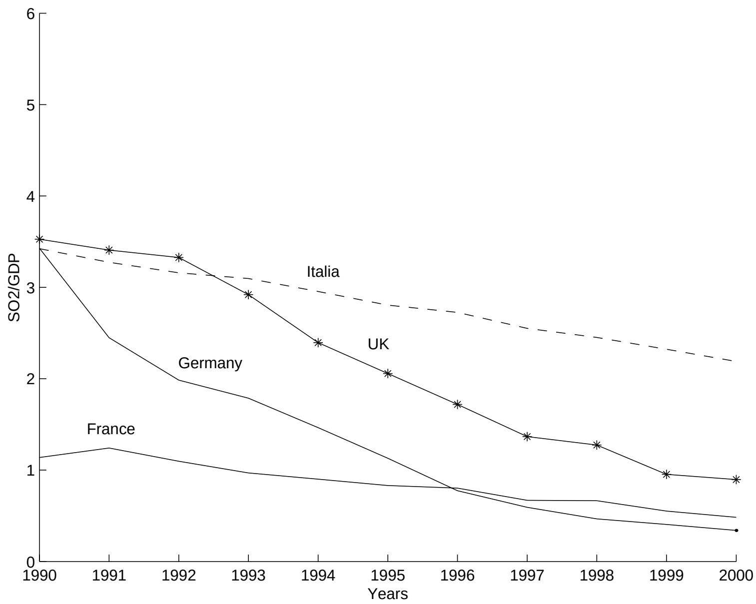

Figure 1: Group 1: SO_2 intensities 1990-2000 (kilograms per thousand dollars)

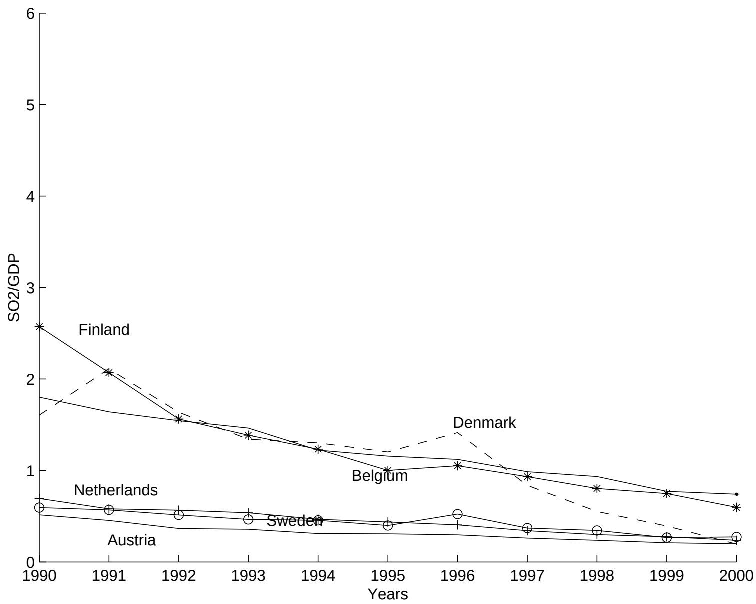

Figure 2: Group 2: SO_2 intensities 1990-2000 (kilograms per thousand dollars)

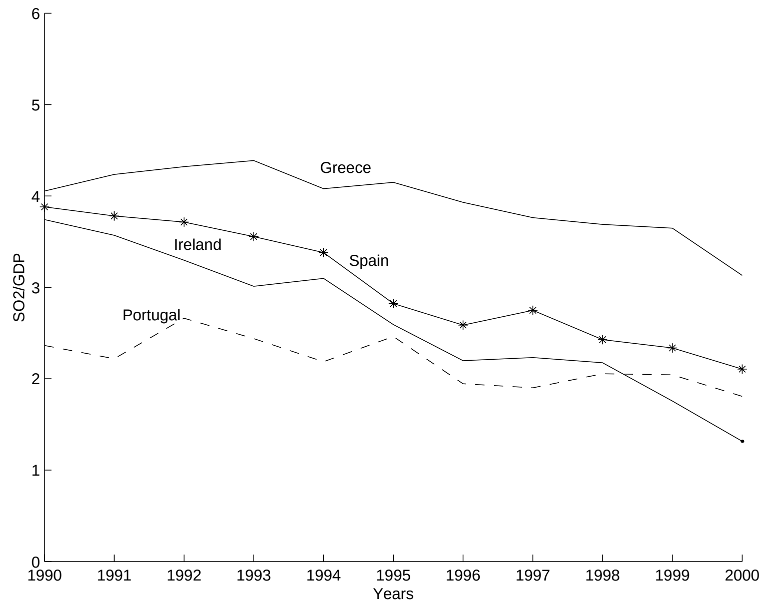

Figure 3: Group 3: SO_2 intensities 1990-2000 (kilograms per thousand dollars)

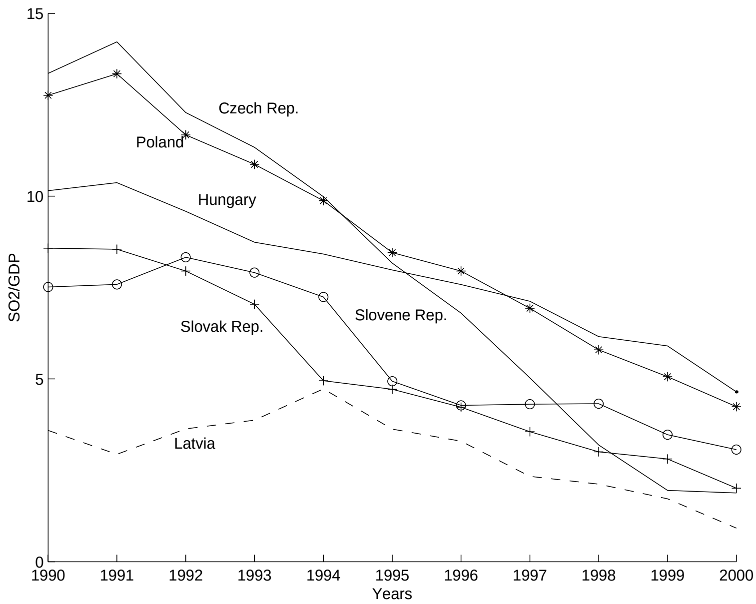

Figure 4: Group 4: SO_2 intensities 1990-2000 (kilograms per thousand dollars)

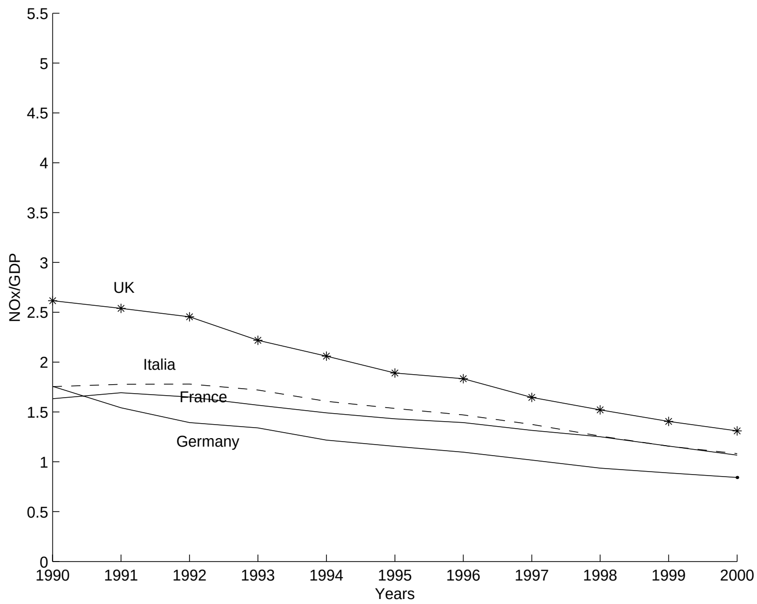

Figure 5: Group 1: NO_x intensities 1990-2000 (kilograms per thousand dollars)

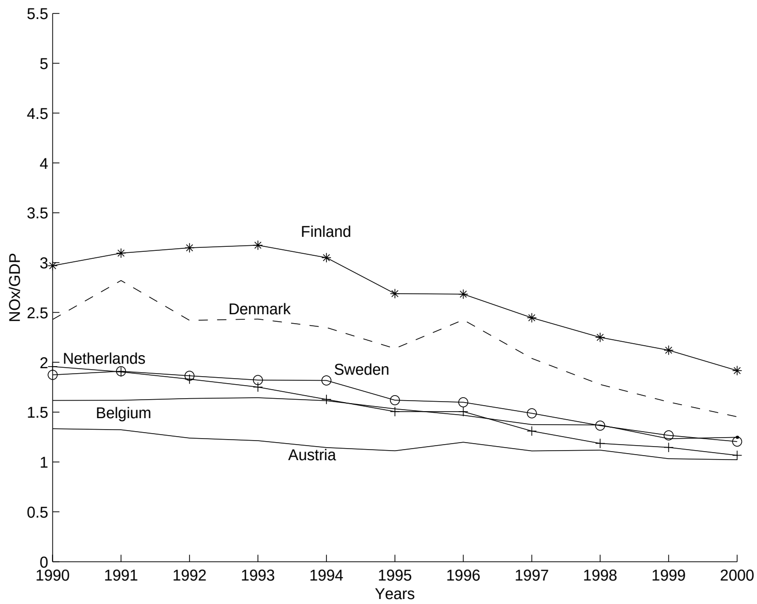

Figure 6: Group 2: NO_x intensities 1990-2000 (kilograms per thousand dollars)

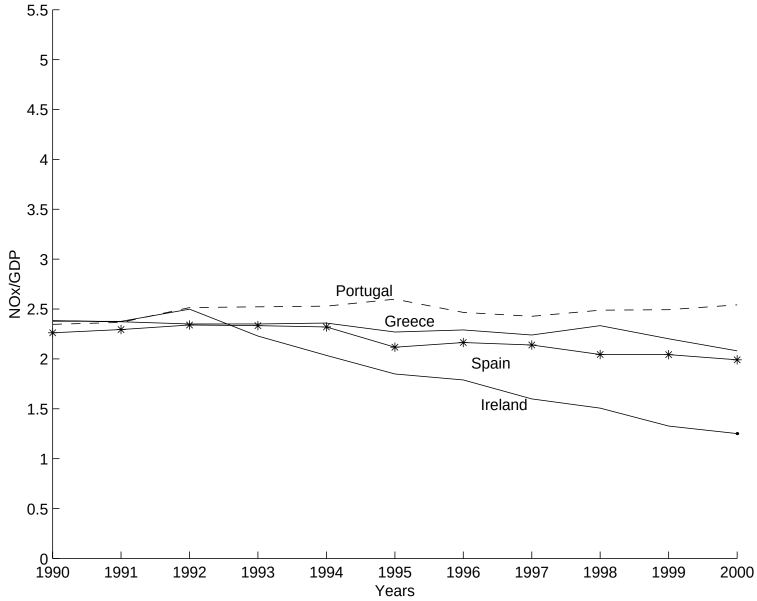

Figure 7: Group 3: NO_x intensities 1990-2000 (kilograms per thousand dollars)

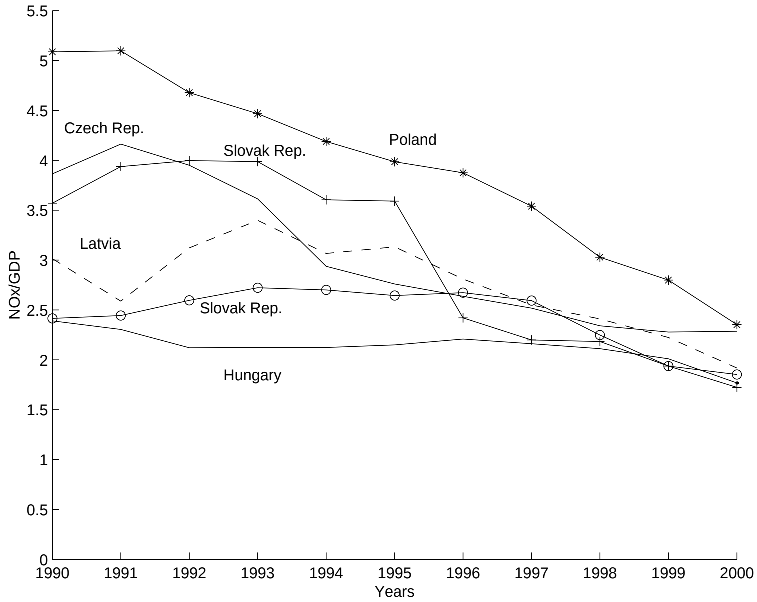

Figure 8: Group 4: NO_x intensities 1990-2000 (kilograms per thousand dollars)

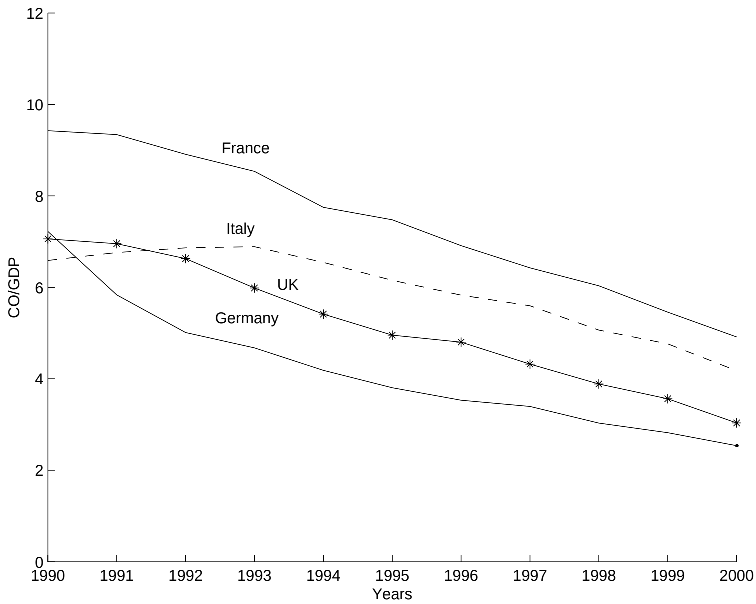

Figure 9: Group 1: CO intensities 1990-2000 (kilograms per thousand dollars)

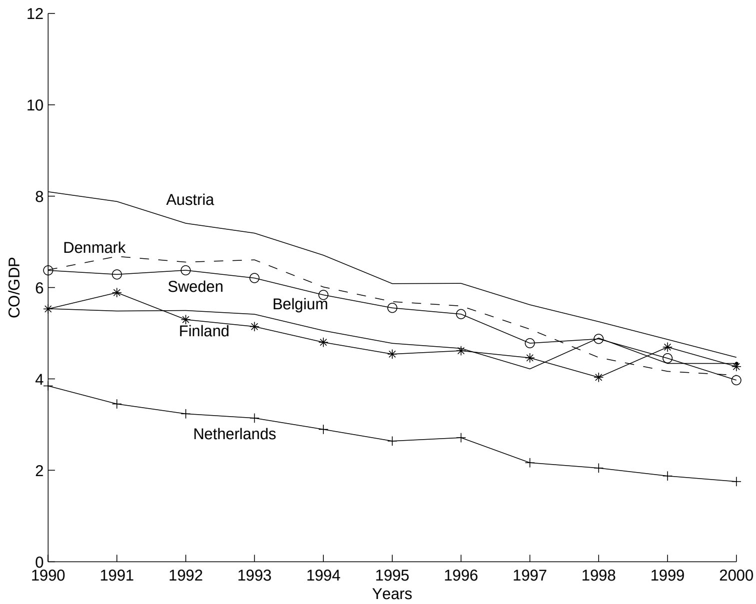

Figure 10: Group 2: CO intensities 1990-2000 (kilograms per thousand dollars)

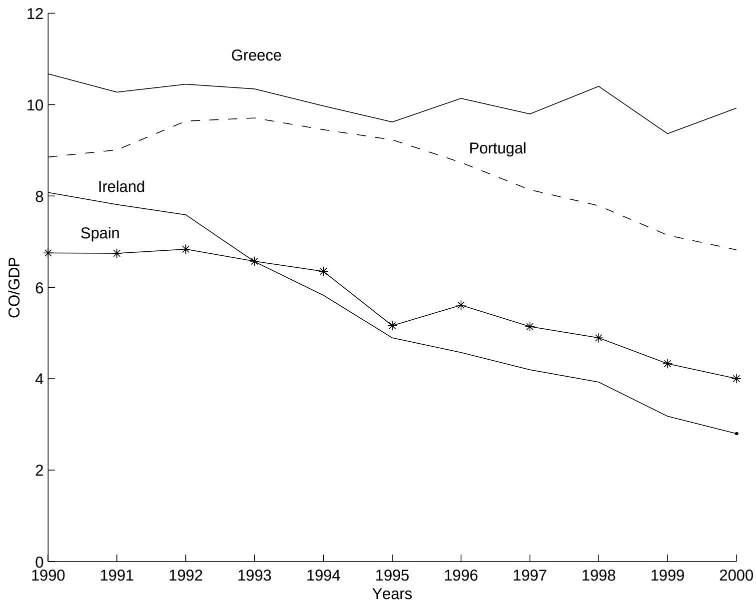

Figure 11: Group 3: CO intensities 1990-2000 (kilograms per thousand dollars)

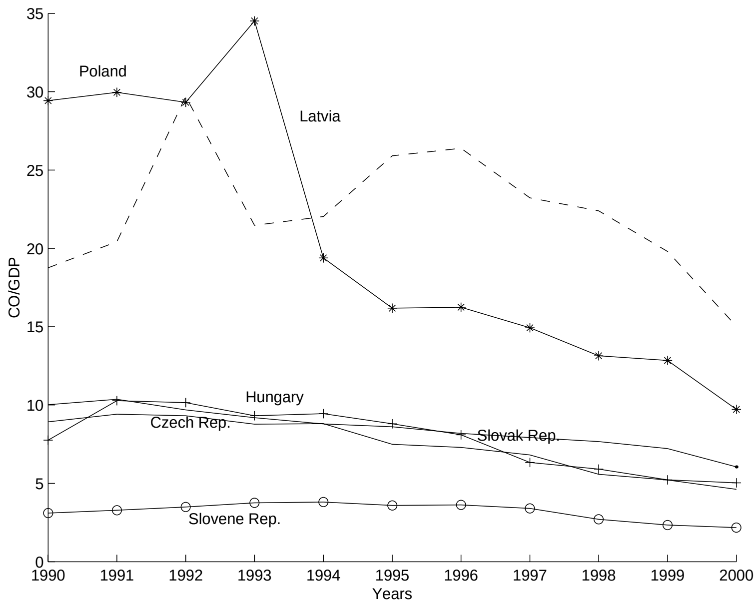

Figure 12: Group 4: CO intensities 1990-2000 (kilograms per thousand dollars)

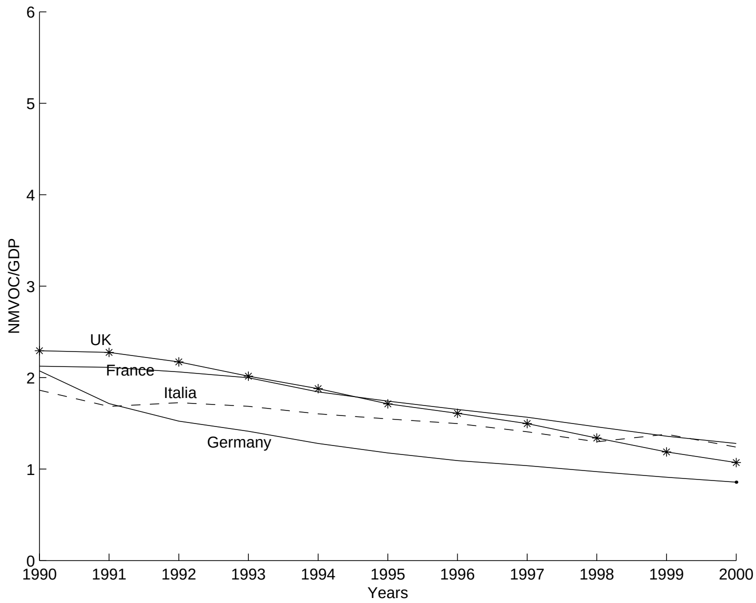

Figure 13: Group 1: $NMVOC$ intensities 1990-2000 (kilograms per thousand dollars)

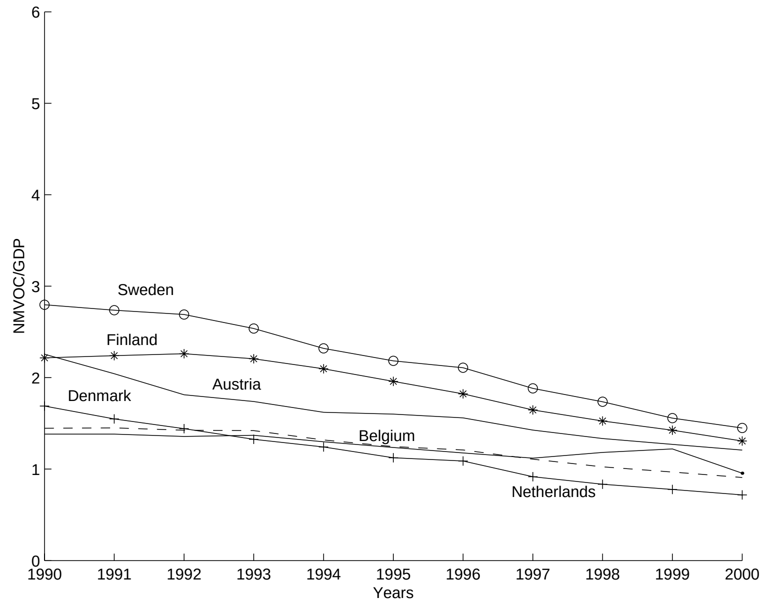

Figure 14: Group 2: $NMVOC$ intensities 1990-2000 (kilograms per thousand dollars)

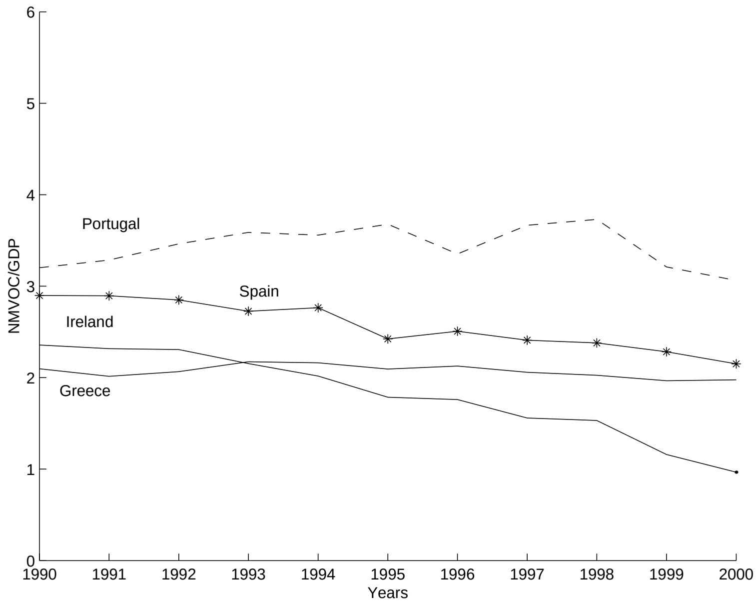

Figure 15: Group 3: $NMVOC$ intensities 1990-2000 (kilograms per thousand dollars)

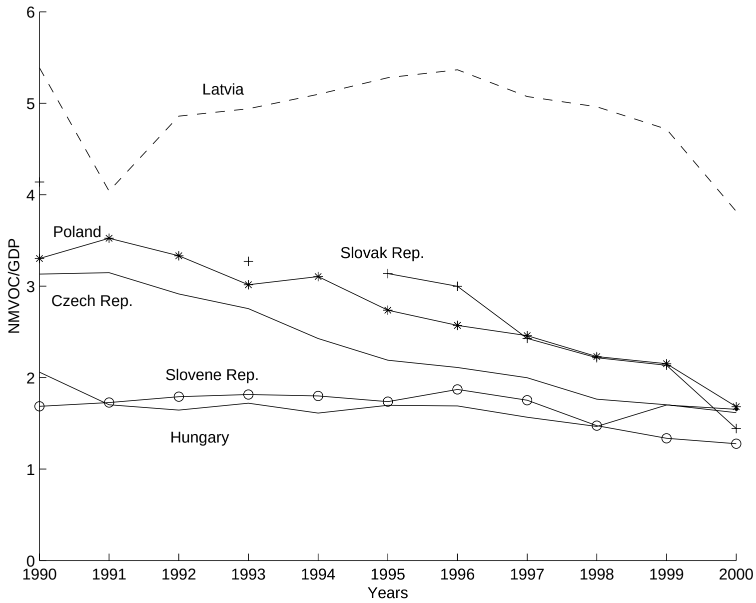

Figure 16: Group 4: $NMVOC$ intensities 1990-2000 (kilograms per thousand dollars)

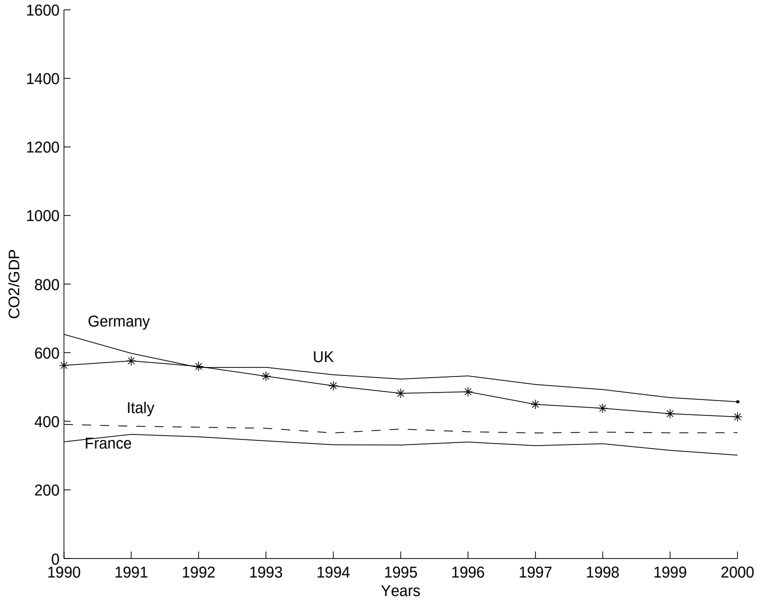

Figure 17: Group 1: CO_2 intensities 1990-2000 (kilograms per thousand dollars)

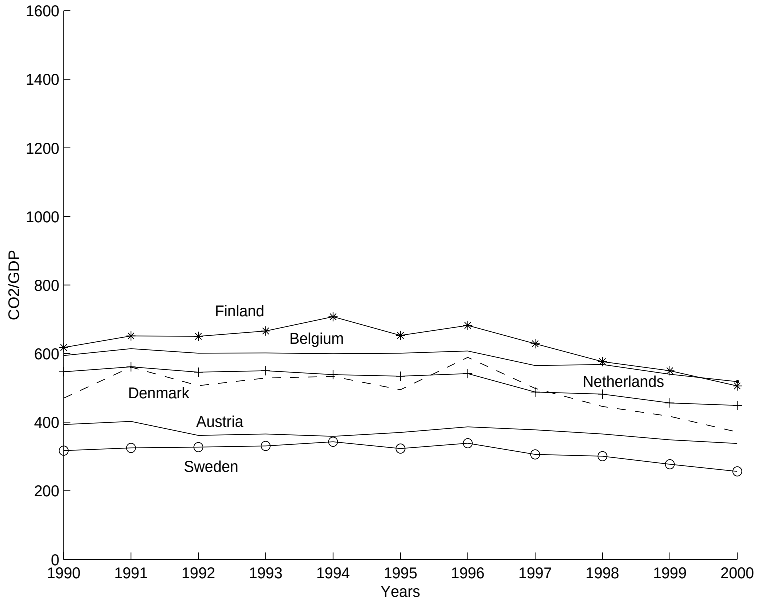

Figure 18: Group 2: CO_2 intensities 1990-2000 (kilograms per thousand dollars)

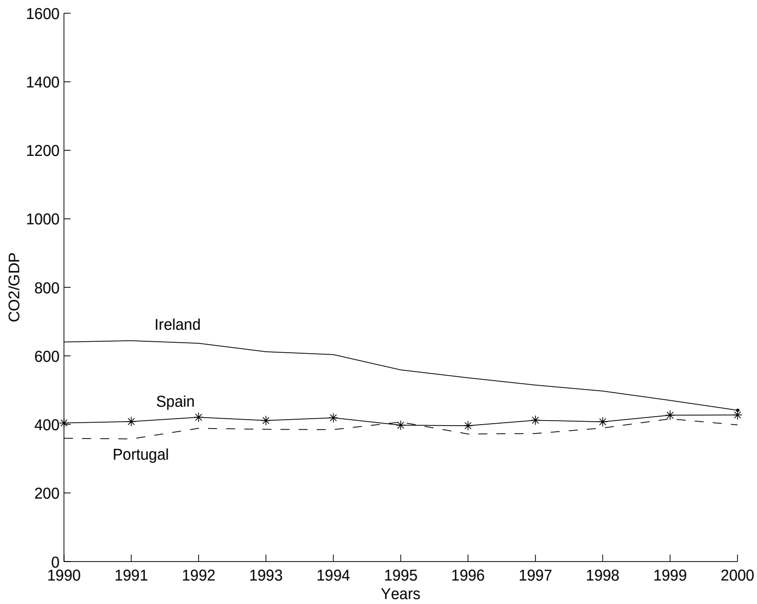

Figure 19: Group 3: CO_2 intensities 1990-2000 (kilograms per thousand dollars)

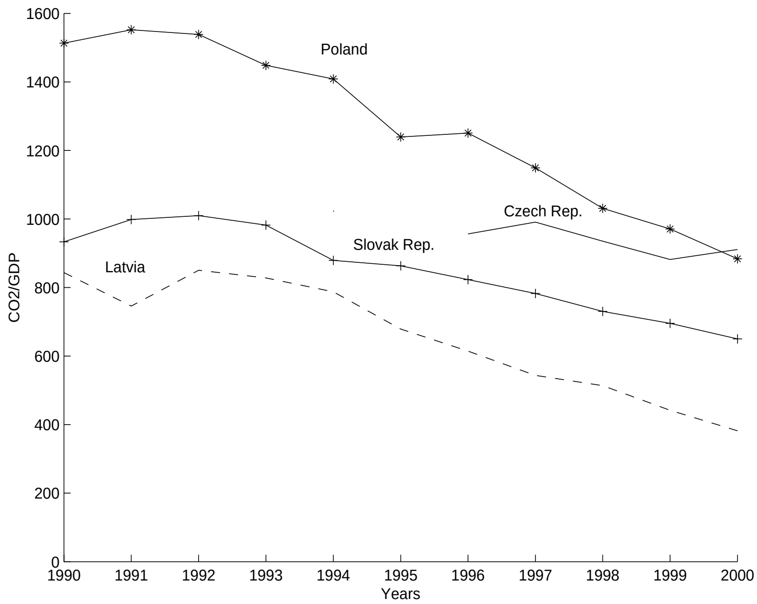

Figure 20: Group 4: CO_2 intensities 1990-2000 (kilograms per thousand dollars)

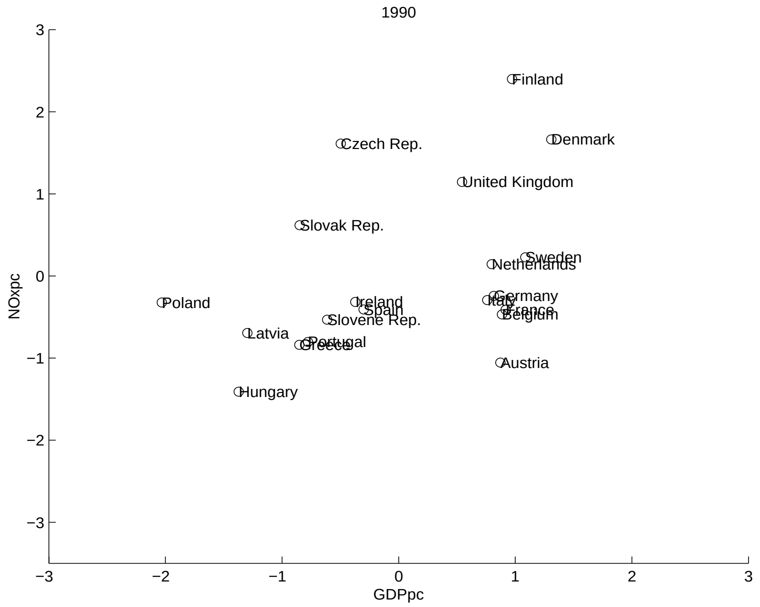

Figure 21: GDPpc versus NO_xpc: standardized values 1990 (base year: 1990)

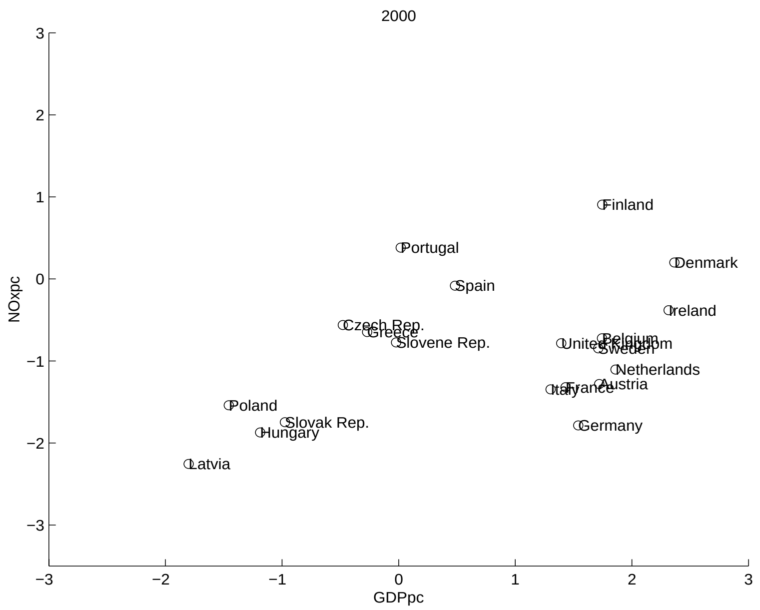

Figure 22: GDPpc versus NO_xpc: standardized values 2000 (base year: 1990)

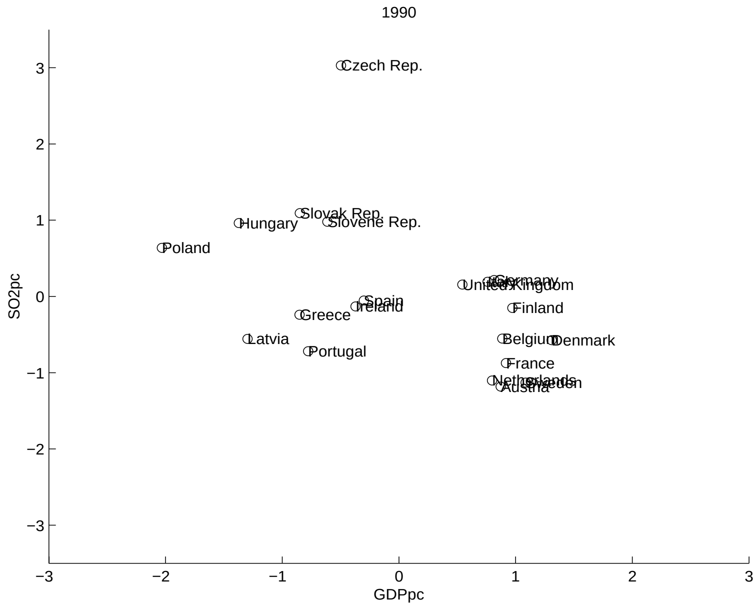

Figure 23: GDPpc versus SO_2pc: standardized values 1990 (base year: 1990)

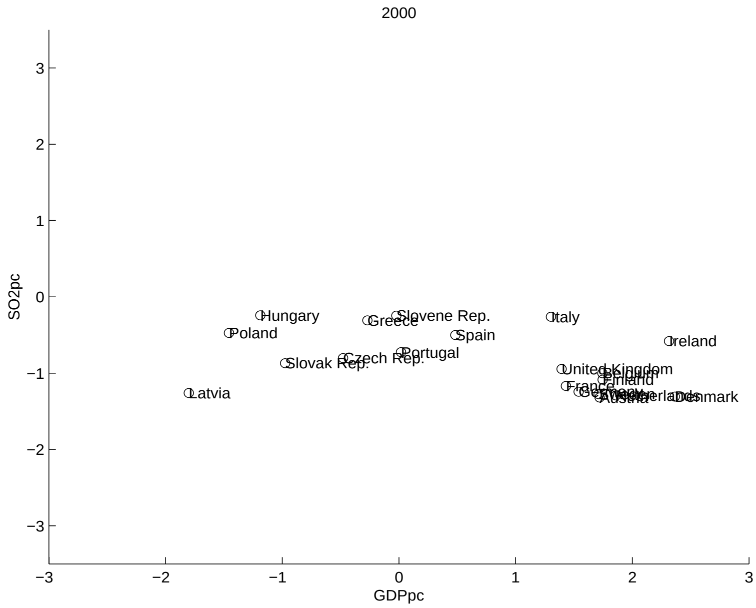

Figure 24: GDPpc versus SO_2pc: standardized values 2000 (base year: 1990)

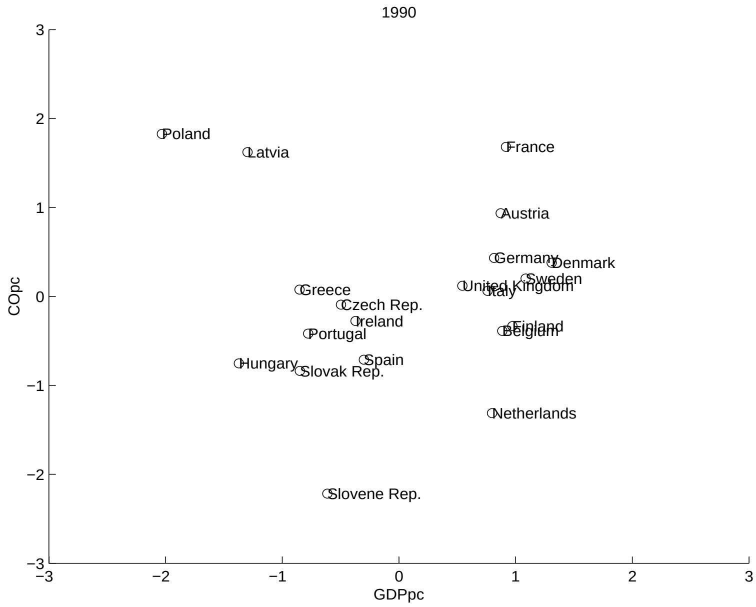

Figure 25: GDPpc versus *COpc*: standardized values 1990 (base year: 1990)

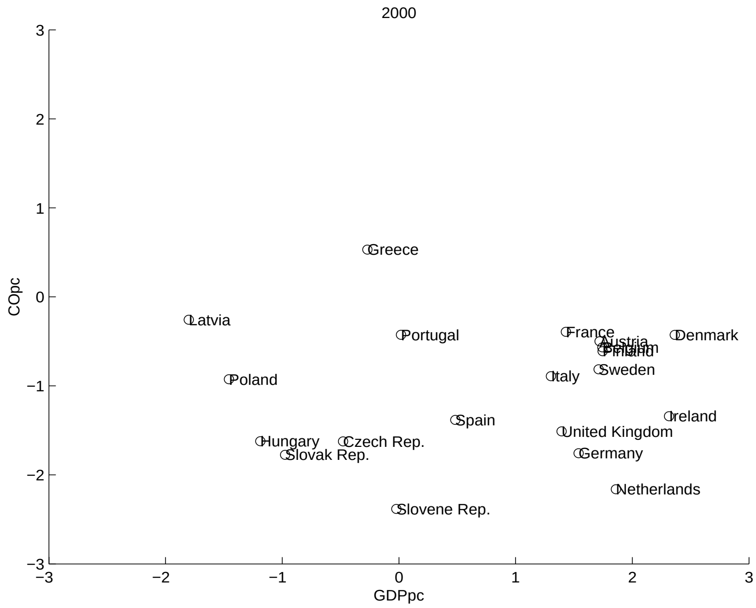

Figure 26: GDPpc versus *COpc*: standardized values 2000 (base year: 1990)

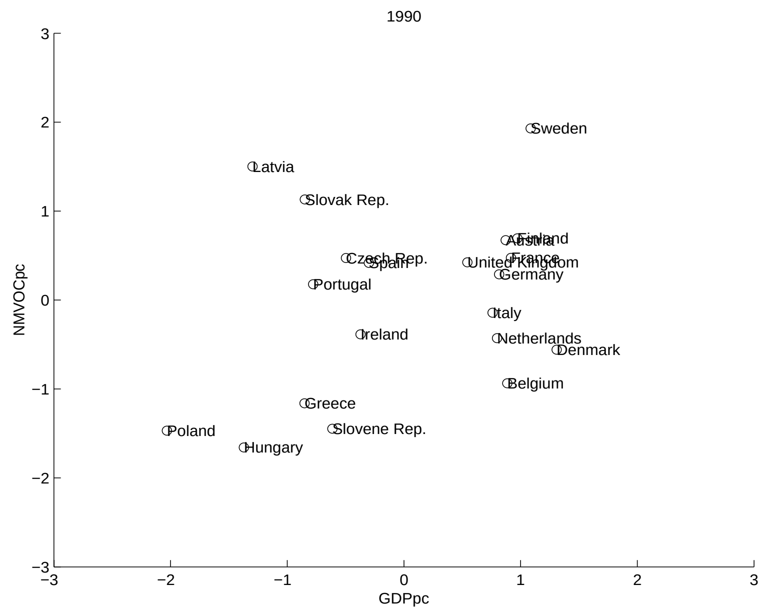

Figure 27: GDPpc versus $NMVOCpc$: standardized values 1990 (base year: 1990)

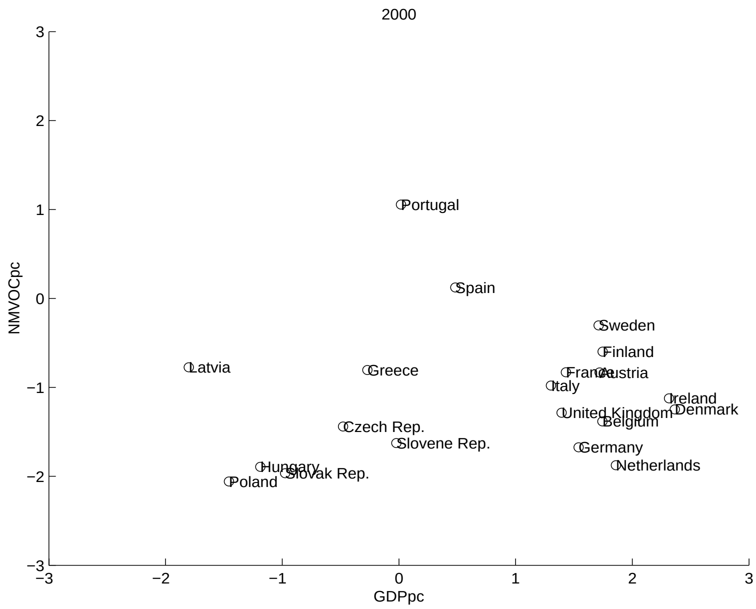

Figure 28: GDPpc versus $NMVOCpc$: standardized values 2000 (base year: 1990)

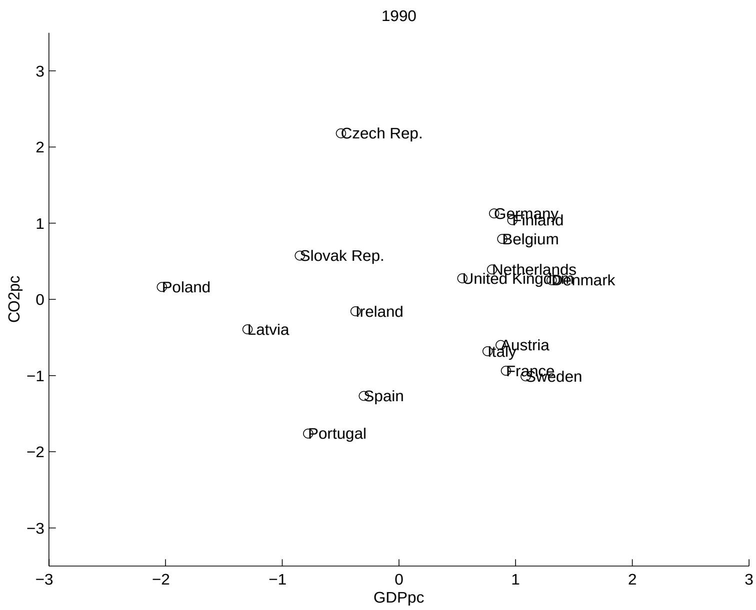

Figure 29: GDPpc versus CO_2pc: standardized values 1990 (base year: 1990)

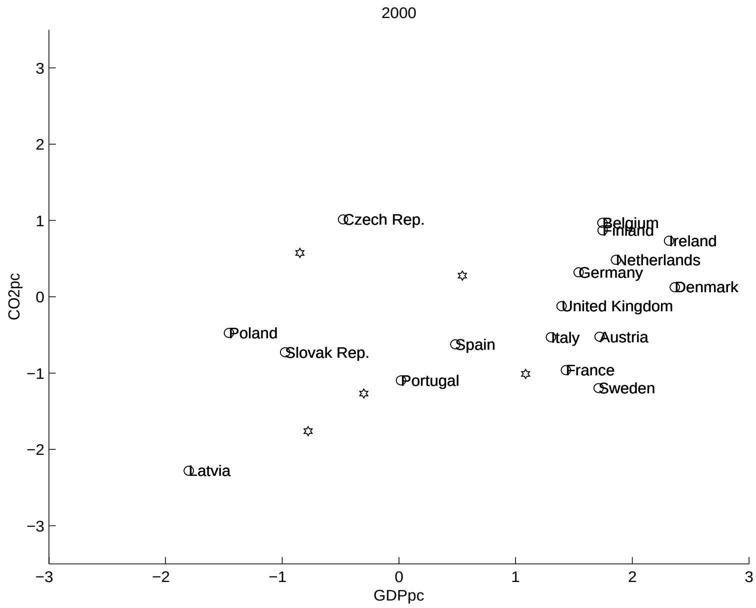

Figure 30: GDPpc versus CO_2pc: standardized values 2000 (base year: 1990)