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Can Redistribution Contribute to Pollution Reductions? An Empirical Evaluation

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Abstract

We test the hypothesis that more progressive redistribution contributes to emission reductions with the aid of the fixed-effects estimation technique. Using a panel of 16 West European countries over the period 1990-99, we regress emission levels of four different air pollutants on two alternative measures of redistribution and additional controls. The results are statistically significant and indicate that redistribution may be an important driving force of environmental improvements.

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1 Introduction

Environmental pollution is a necessary by-product of economic activity. Exceeding certain threshold levels, air and water pollutants from anthropogenic sources can be severely damaging to human health and threaten the stability of eco-systems. Within the economic research community devoted to the topic, there is a broad consensus that laissez-faire policies fail to limit pollution to acceptable levels. What is needed, in turn, is a conscious engagement of the state, caring for clean environment without possibly compromising consumption wishes of the (voting) population. A problem which arises immediately is the fact that there is no clear idea what kind of political activity is actually required. Therefore, it can only be speculated about potentially effective policy prescriptions to be designed in order to solve the environmental-economic problem. We argue that one of the means contributing to better environmental quality could be progressive redistribution, a completely empirically overlooked channel linking the structure of economic activity, molded by power, wealth and income inequalities and the environment. Additionally, we would like to examine the influence of left-wing parties, traditionally more inclined to redistribute, on the measured emissions. Using the fixed effects estimation technique we are able to test the prediction empirically, accounting for time-invariant unobserved heterogeneity in the countries under investigation. The results we obtain appear to support our expectations toward the role of redistributive policies in diminishing environmental degradation. Section 2 presents the theoretical foundation of the empirical analysis, as well as the contributions of related literature and the variables used in the regressions. Section 3 describes the econometric method, while section 4 provides the description of the data used. The results of our study are contained in section 5, and some robustness checks are discussed in section 6. Conclusions are given in section 7.

2 Conceptual framework

We derive our hypotheses from Drosdowski (2005, 2006), which provide the theoretical link between inequality and environmental pollution via redistribution. The theory predicts that progressive taxation may improve environmental quality, by reallocating a share of redistributed incomes (or wealth) from polluting consumption and investment to abatement activities, given a constant level of regulation reflecting a society's preferences. The progressivity of redistribution increases with more equal political power (reflecting income/wealth inequality) between decisive political forces and a poorer median voter, which could be described as a democratization, and this increase reduces pollution. Political regimes redistributing more progressively are thus expected to implement and maintain higher levels of environmental protection leading to less pollution. Given the fact that we are only able to analyze established West European democracies where substantial improvements in democratic practice over a ten-year span are unlikely, we concentrate on the "maintenance"-aspect of redistributive policies. Strong redistributive policies are often found in leftist political regimes, which provides an alternative view and interpretation of the link between inequality and pollution, as discussed in Drosdowski (2005). Following a similar line of reasoning, a leftist regime will redistribute funds in a more progressive way, ultimately protecting the environment more effectively.

To test the hypotheses, we will regress air pollution levels per capita (POLL) on a measure of fiscal redistribution and additional controls. We use two alternative proxies for fiscal redistribution. To obtain the first one, we compute Gini-indices for market and disposable income and use the difference in Ginis as an explanatory variable (RED) (see Table 6 in appendix A1). In this way, the difference between income inequality after taxes and transfers and inequality prior to redistribution shows the extent of governmental activities aimed at reducing inequality. Due to a severely limited number of observations, we also employ another measure, which is the share of social expenditures in GDP (SOCX), for which our data is much more comprehensive. The main problem with this second measure, however, may be the fact that it is not generally accepted as a pure measure of redistribution, being an imperfect indicator. Milanovic (2000) argues that it is not correct to use the share of government transfers because "a society with high taxes and transfers may have contributors and beneficiaries who are the same people" (ibid., p. 370), and most transfers would flow to the middle class. Nevertheless, sometimes alternatives are not available and government expenditure as a GDP-share is commonly used in the literature, among other measures such as marginal tax rate, tax revenue or total revenue as a share of GDP. Therefore, as well as due to the dramatically increased explanatory power of regressions with SOCX, we are willing to accept it as our second redistribution measure.

The influence of leftist parties on the environmental quality has been extensively analyzed in Neumayer (2003) and Jahn (1998). The literature cited by the authors, predominantly from the realm of political science, discusses several possible explanations why left parties would contribute to more or less environmental damage. On the one hand, traditional left-wing parties could oppose environmental policies to promote economic growth and secure jobs in polluting sectors. On the other hand, they may advocate environmental interventionism under the pressure of activist groups, for instance in order to absorb green electorate or as a compromise with green coalition partners. Moreover, socialist or social democratic parties with rather egalitarian agendas could be inclined to protect the poor that are likely to be primarily exposed to pollution. However, no previous empirical study has considered redistribution as a potential engine of environmental improvements.[1] The authors do not generally conclude that left-party strength is negatively correlated with pollution levels across countries. Rather, they find out that the left-wing presence in cabinets is associated with higher, although quantitatively negligible, pollution levels, whereas their presence in parliaments appears to improve some aspects of environmental quality in OECD countries. Green parties' impact on pollution reduction is showed to be significant. In our investigation, we account for left-party strength in exactly the same manner as Neumayer (2003), including left cabinet portfolios as a share of all cabinet portfolios (LEFTC), left governing party seats as a percentage of all legislative seats (LEFTS) and the percentage of seats for left-libertarian parties (LEFTL).

In Drosdowski (2006), initial inequality levels are important for the direction of transitional paths of endogenous variables towards a steady state. Therefore, we create a dummy variable for high and low initial inequality and compute an interaction term with redistribution (INQ). Believing that redistribution is a driving force for pollution reductions, which results from pre-tax inequality (see Milanovic 2000), we abstain from studies that include contemporaneous measures of inequality in panel regressions and thereby avoid this type of multicollinearity issues. Inequality itself, measured by the

[1] Boyce (1994) can be credited for being the first one to discuss the polluting influence of regressive redistribution theoretically.

Gini-coefficient or an appropriate ratio of some bottom and top quantiles in the income distribution, has not performed well as an explanatory variable in previous empirical contributions concerned with environmental quality. As a response to Boyce (1994) containing the hypothesis that bigger income inequality will c.p. lead to more environmental degradation, Scruggs (1998), criticizing many aspects of Boyce's paper on theoretical grounds, does not find convincing empirical evidence for a generally significant positive relationship between income inequality and several measures of environmental quality. In the first set of regressions using pooled cross sections only two of the considered air and water pollutants (dissolved oxygen, fecal coliform, sulphur dioxide and particulate matter) have significant coefficients and one of them the expected sign. In the second part with a composite index of environmental quality, income inequality measures have unexpected signs in two tested specifications, out of which one is barely significant. Torras and Boyce (1998) also obtain inconsistent results in their OLS-regressions of seven pollutants on a number of controls, including income inequality. For sulphur dioxide and smoke, the inequality coefficient is significant and positive in low income countries, while being negative in high-income countries. Additionally, in poorer countries inequality is negatively correlated with access to water and ambient concentrations of particles and dissolved oxygen.[2] These findings are compatible with Drosdowski (2005), in which marginal inequality increases, i.e. the increased variance of income distribution, do not exert much influence on pollution levels. If anything, a more unequal distribution results in slightly lower pollution.

A much more important issue concerns power inequality, which is expected to cause higher pollution by a reinforcement of less progressive redistribution, as explained above. Boyce (1994) was arguably the first one to point in this direction, perceiving income inequality as one of the aspects of power inequality. As Payne (1995) stated, better information, possibility to articulate legitimate demands, organization of interests and exerting influence in the political process in democracies should contribute to environmental protection. Empirical research linking proxies for democracy and democratic freedoms and environmental performance generally shows much more support for this notion. In Torras and Boyce's (1998) regressions, using adult

[2]Ravallion et al. (1997) and Borghesi (2000) test the relationship between carbon dioxide and income inequality, obtaining rather poor statistical evidence. Since we are not primarily concerned with global pollution, we do not discuss these papers in detail.

literacy and a Freedom House index of rights and civil liberties, both proxies for power equality have in most cases significantly negative impact on pollution levels, especially in poorer countries. Deacon (1999) shows that the provision of environmental protection (better access to safe water and sanitation, lower lead concentrations) is higher in democracies, that in general provide more public goods than non-democracies.[3] Barrett and Graddy (2000) also use the indices for political and civil freedoms from the Freedom House, providing evidence that an increase in freedoms improves environmental quality for some air pollutants. They convert the indices to a continuous 0-1 scale, which enter the regressions directly or as grouped dummies (low, middle or high freedom). Moreover, the variables enter the random and fixed effects estimations as a four-year moving average. The evidence obtained is rather weak. A combined freedom index, however, displays statistical significance for sulphur dioxide, smoke and heavy particles. Harbaugh et al. (2002) detect a significantly negative relationship between the Polity III index of democracy and the air pollutants sulphur dioxide, smoke and suspended particulate matter. Concentrating solely on sulphur dioxide concentrations, measured in 42 developing and developed countries between 1971 and 1996, Bernauer and Koubi (2004) provide evidence that a higher ratio of winning coalition size and the size of "selectorate", used by the authors in accordance with a theory of Bueno de Mesquita et al. (2003) as a democracy proxy, significantly improves environmental quality.[4] Furthermore, their random effects estimation shows that civil liberties are also conducive to environmental improvements. However, when green party strength and labor power is included, civil liberties exert a negative influence on the environment, indicating that green parties may be a powerful pressure group contributing to lower pollutant concentrations.[5] On the other hand, Scruggs (1998) finds a significant pollution reduction due to democratization only in the case of sulphur dioxide, using a combined Freedom House index. Neumayer (2002) considers the overall evidence as weak, arguing that it might be more problematic to control and avoid environmentally damaging activities in democracies by force, as opposed to non-democracies. Furthermore,

[3]He uses the Polity III data base for his democracy proxy (see section 6 for a description of the follow-up data base Polity IV), instead of a Freedom-House measure due to a "common belief that it reflects a conservative bias" (Deacon 1999, p. 15).

[4]Selectorate is a group influencing the choice of leaders in exchange for benefits.

[5]Labor strength is positively correlated with SO_2-concentrations.

there are various factors deciding about the environmental quality which are not influenced by democratic governments, e.g. soil degradation or the historically determined mix of energy sources. Instead, he concentrates on the formal environmental commitment of democratic countries, expressed in international treaties, showing that, indeed, democracies are more likely to sign and ratify multilateral agreements, participate in organizations or provide more ecologically related information for citizens.

Finally, we include real gross domestic product per capita (GDP), which is a standard control in empirical studies concerned with the determinants of environmental pollution. It might be hard to argue that the production of physical output for consumption purposes is not the main source of anthropogenic pollution. One might ask why there is no environmental policy variable involved. First, there is no reliable air pollution abatement data available. Second, a fixed-effects estimation allows us to account for an unobserved heterogeneity in environmental regulations, beliefs and traditions across countries.

3 Estimation Method

Using fixed-effects estimation methods, we test the following specifications empirically:

$$\begin{aligned}\ln(POLL_{it}) = \beta_1 RED_{it} + \beta_2 \ln(GDP_{it}) + \beta_3(\ln(GDP_{it}))^2 \\ +\beta_4(\ln(GDP_{it}))^3 + \beta_5 LEFTC_{it} + \beta_6 LEFTS_{it} + \beta_7 LEFTL_{it} \\ +\beta_8 INQ_{it} + a_i + u_{it}\end{aligned} \tag{1}$$

and

$$\begin{aligned}\ln(POLL_{it}) = \gamma_1 SOCX_{it} + \gamma_2 \ln(GDP_{it}) + \gamma_3(\ln(GDP_{it}))^2 \\ +\gamma_4(\ln(GDP_{it}))^3 + \gamma_5 LEFTC_{it} + \gamma_6 LEFTS_{it} + \gamma_7 LEFTL_{it} \\ +\gamma_8 INQ_{it} + a_i + u_{it},\end{aligned} \tag{2}$$

where i represents the cross-sectional unit (country) and t time. a_i is the unobserved country heterogeneity, which is allowed to be correlated with the explanatory variables. It disappears from the analysis due to so called fixed effects transformation. The idiosyncratic error term u_{it} captures the unexplained part of the variation and must not be correlated with any explanatory variable in any time period, in order to obtain unbiased estimators.

A random effect estimation, which includes the variation between countries in addition to the variation within each country, under the condition that the unobserved effect is uncorrelated with the regressors, has been ruled out by the Hausman test, because the estimated coefficients in the fixed effects and the random effects estimations systematically differ from each other. It would be hard to assume anyway, that unobserved country effects such as resource endowments or environmental policies would be uncorrelated with explanatory variables such as income, as pointed out by Borghesi (2000, p. 12). Moreover, random effects are primarily used, when data are randomly drawn from a larger population. In addition to the usual standard errors, we will also report robust standard errors. We use a logarithmic dependent variable, as well as logs of income as independent variables. It allows us to conveniently interpret the estimated coefficients. The coefficient for redistribution multiplied by one hundred then gives the approximate percentage change in the level of an examined pollutant when redistribution increases by one unit (semi-elasticity of pollution with respect to redistribution). Additionally, using logs is a remedy for heteroskedasticity and skewness in distributions with positive variables, and it renders the estimates more robust to outliers (Wooldridge 2003, p. 188). Both functional specifications include a squared and a cubic GDP-term, which is often found in the empirical literature linking pollution to income, indicating an N-shaped (or S-shaped) functional relationship (see De Bruyn et al. 1998). This non-linear relationship is usually called the environmental Kuznets curve (EKC). The GDP-terms account for the scale, composition and technique effects associated with the income-pollution relationship.

4 Data

The analyzed air pollutants are sulphur oxides (SOx), nitrogen oxides (NOx), carbon monoxide (CO) and volatile organic compounds (VOC).[6] Table 7 in appendix A2 contains information about the pollutants' sources and their impact on the environment and human health. The pollution data is provided by the European Environment Agency and stems from the EMEP program (Co-operative Programme for Monitoring and Evaluation of the Long-Range

[6]SOx is a broad term referring to sulphur dioxide (SO_2) and trioxide (SO_3), while NOx includes nitric oxide (NO), nitrogen dioxide (NO_2) and nitrous oxide (N_2O).

Transmissions of the Air Pollutants in Europe), which reports emission levels instead of ambient concentrations.[7] Hence, it accounts for pollution sources and neglects the aspects of transboundary pollution, thereby suiting the theory well, which is concerned with pollution from local sources. It covers the period 1990-99 for 16 West European countries.[8] The pollution levels are normalized by population totals in the countries, accounting for size differences between them. The unit of measurement is gigagram per capita, or one thousand tons. The same normalization is made for real GDP levels in constant 2000 US PPP dollars. Both GDP and population data are taken from the World Bank (2005). The first redistribution measure (RED) is computed using data from the Luxembourg Income Study (LIS), which is a unique source of internationally comparable inequality data stemming from household surveys. The differences in Ginis we use are calculated following the LIS methodology and definitions of market income as well as disposable income.[9] In short, market income consists of factor income (salaries, wages, self-employment income, cash property income) plus private and occupational public pensions. Disposable income, on the other hand, is gross income (market income, social security benefits and other income) minus mandatory contributions for employees and self-employed minus income taxes. Unfortunately, as already explained, the number of observations is rather small, corresponding to a low number of degrees of freedom, which may contribute to a limited explanatory power of the empirical test. This is due to the fact that the LIS database lacks yearly statistics for all covered countries. They are provided in waves, out of which we can use Wave III-V for the relevant time period of the study. Therefore, the panel used to estimate equation (1) is unbalanced. As mentioned earlier, our alternative redistribution measure (SOCX) represents the GDP-share of total public social expenditure (in %) for each country and year. It stems from OECD (2004) and contains benefits (cash or in-kind) for old age, survivors, disability, health, family, unemployment, housing as well as active labor market programmes. The variables indicating the political strength of leftist parties are provided by

[7]The data is available online at http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=762.

[8]The countries from which data is provided are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

[9]They are found online under http:\\www.lisproject.org.

Swank (2002) in his panel containing data for 21 capitalist democracies for years 1950-99. Left parties are communist, socialist, social democratic, labor and other left-wing parties. Left-libertarian parties are essentially identical with green parties (e.g. Alliance 90/Greens in Germany). The initial inequality dummy, which we use in the interaction term with redistribution (INQ) is created by an arbitrary division of Gini indices stemming from the Deininger and Squire (1996) data set into high and low ones. This inequality data source is the most popular, and may be the best currently available one for international comparisons including a large number of countries at long time-horizons, despite severe problems involving data comparability, measurement issues or missing data points (see Atkinson and Brandolini 2001). Due to the scarcity of observations before 1980, we employ those around this year and define high inequality as one associated with a Gini value over 30. In this case the binary variable interacted with redistribution will have the value one.[10] The following table displays the variables and the units of measurement. The number of observations in the panel is 160 in case when

POLL	pollution level in Gg per capita
GDP	gross domestic product per capita in 2000US$
RED	difference between market and disposable income Ginis
SOCX	social expenditures in % of GDP
LEFTC	share of cabinet portfolios held by left-wing parties in %
LEFTS	share of legislative seats held by left-wing parties in %
LEFTL	share of legislative seats held by left-libertarian parties in %
INQ	initial inequality (1=high,0=low) interacted with RED or SOCX

Table 1: Variable description.

SOCX is included, and 31 when RED is used. In the second case, the number of countries is reduced to 15, since there is no data for left-party strength for Portugal. The summary statistics are included in appendix A4.

5 Results

The results contained in Tables 2-5 strongly support the hypothesis that redistributive measures contribute to reductions in the observed pollution levels. Below each estimated coefficient we report absolute t-values without

[10]See appendix A3 for the full list of initial Ginis.

and with robust standard errors, respectively. Table 2 displays the fixed-effects estimation results for the analyzed four pollutants with RED as the redistribution measure (equation (1)).

	SOx	NOx	CO	VOC
RED	-.078	-.031	-.046	-.039
	(7.50)***	(5.03)***	(7.16)***	(3.52)***
	(8.15)***	(7.28)***	(8.55)***	(2.70)**
GDP	4080.825	4153.943	2823.264	5624.119
	(4.54)***	(7.88)***	(5.07)***	(5.81)***
	(4.97)***	(10.76)***	(5.13)***	(5.37)***
GDP^2	-408.404	-414.665	-282.331	-562.64
	(4.54)***	(7.86)***	(5.07)***	(5.80)***
	(4.98)***	(10.75)***	(5.12)***	(5.38)***
GDP^3	13.610	13.791	9.402	18.753
	(4.54)***	(7.84)***	(5.06)***	(5.80)***
	(4.99)***	(10.75)***	(5.12)***	(5.38)***
LEFTC	.001	.000	-.001	-.000
	(2.42)**	(.19)	(.91)	(.01)
	(2.82)**	(.23)	(1.27)	(.01)
LEFTS	-.003	-.001	.-001	.001
	(4.17)***	(.39)	(.92)	(.22)
	(4.43)***	(.46)	(1.24)	(.25)
LEFTL	.011	-.008	-.010	-.027
	(.20)	(1.25)	(1.47)	(2.40)**
	(.28)	(1.22)	(1.49)	(2.09)*
Observations	31	31	31	31
R^2 within	.99	.97	.98	.93
R^2 between	.44	.04	.00	.00
R^2 overall	.55	.12	.00	.01

Note: Absolute t values are included in parentheses.
* Significant at 10% level.
** Significant at 5% level.
*** Significant at 1% level.

Table 2: Results for pollution levels with RED.

It shows that the estimated coefficients for RED are in all cases negative and significantly different from zero for all examined air pollutants, which indicates that redistribution may be an important link between inequality and pollution, as theoretically expected. Income effects are also statistically significant, and the relationship between per capita income and emissions is nonlinear, supporting the standard view from the EKC-research. Political variables do not exert much influence on the dependent variables, despite the fact that their coefficients in most cases have the expected signs, obtained in Neumayer (2003). Neumayer's study is only one of few others we are aware of, which use EMEP pollution data (augmented by emissions data for other OECD countries).[11] In case of SOx, left cabinet strength is associated with significantly higher emissions, whereas left party strength in parliaments is negatively correlated with pollution. In the VOC-regression, however, only the variable indicating the strength of libertarian/green parties is significantly negative with respect to emissions. Neumayer's estimations yield the same result with respect to VOC but different ones for other pollutants, i.e. for CO and NO_2 all political variables are significant, and for SO_2 only LEFTL is significant. The inclusion of the interaction term between initial inequality and the redistribution level does not change the results in any substantial way (Table 3). Whereas the interaction term is never significant, it does slightly reduce the statistical significance of the other explanatory variables. Still, they are mostly significant, with the exception of RED in the VOC-equation with robust standard errors. The same applies to left cabinet strength, where the statistical significance drops below the 0.1 level.

A somewhat different picture emerges when SOCX is used as the proxy for redistribution, suggesting that both employed measures could be considered as different aspects of redistribution. Total public social expenditure as a share of GDP may be more of a proxy for public goods provision with a strong redistributive character, rather than a genuine redistribution variable. There may be some complementarity between both measures, even though the correlation coefficient between RED and SOCX is rather high (40.8 in a full sample and 65.1 when the number of observations is 31). Table 4 displaying the results of regressions without INQ supports the main finding that pollution levels are negatively related to redistribution.

The coefficients of SOCX are highly significant and negative in all cases. Once again, pollution appears to follow the N-shaped income-path confirmed in many EKC-studies. The explanatory variables representing left party strength have a higher impact on pollution levels than before. Especially left-libertarian party strength and left party seats percentage are always statistically significant and have the expected negative signs. The former

[11]We use an updated data set from March 2005, containing sulphur and nitrogen oxides instead of dioxides, which does not make much quantitative difference.

	SOx	NOx	CO	VOC
RED	-.075	-.036	-.052	-.050
	(3.70)***	(3.06)**	(4.26)***	(2.35)**
	(4.00)***	(3.61)***	(4.69)***	(1.74)
GDP	4087.706	4136.564	2802.104	5588.312
	(4.29)***	(7.52)***	(4.86)***	(5.56)***
	(4.69)***	(9.74)***	(4.78)***	(5.07)***
GDP^2	-409.197	-412.663	-279.893	-558.514
	(4.29)***	(7.49)***	(4.85)***	(5.55)***
	(4.70)***	(9.67)***	(4.75)***	(5.08)***
GDP^3	13.640	13.715	9.311	18.597
	(4.28)***	(7.46)***	(4.83)***	(5.54)***
	(4.70)***	(9.60)***	(4.71)***	(5.09)***
LEFTC	.003	.001	.001	.001
	(1.69)	(.49)	(1.08)	(.38)
	(1.49)	(.50)	(1.18)	(.39)
LEFTS	-.010	-.001	.-002	-.001
	(2.81)**	(.65)	(1.08)	(.26)
	(2.36)**	(.66)	(1.07)	(.27)
LEFTL	.003	-.009	-.011	-.03
	(.22)	(1.31)	(1.54)	(2.40)**
	(.26)	(1.17)	(1.36)	(2.17)*
INQ	-.004	.011	.013	.022
	(.13)	(.55)	(.64)	(.62)
	(.11)	(.51)	(.60)	(.53)
Observations	31	31	31	31
R^2 within	.99	.97	.98	.93
R^2 between	.45	.02	.01	.06
R^2 overall	.56	.08	.03	.12

Note: Absolute t values are included in parentheses.
* Significant at 10% level.
** Significant at 5% level.
*** Significant at 1% level.

Table 3: Results for pollution levels with RED and INQ.

variable's explanatory power confirms the findings by Neumayer (2003) as well as by Bernauer and Koubi (2004). The latter is insignificant for SO_2 and VOC in Neumayer (2003). Left-cabinet strength is significantly positive in cases of SOx and CO. In Neumayer's article it is only significant for NO_2 and CO.

Contrary to the regressions with RED, in which the inclusion of INQ does

	SOx	NOx	CO	VOC
SOCX	-.089	-.029	-.044	-.037
	(8.77)***	(7.47)***	(9.29)***	(7.26)***
	(9.87)***	(6.20)***	(8.23)***	(6.59)***
GDP	2780.121	1657.78	1192.853	2100.296
	(5.26)***	(8.27)***	(4.85)***	(7.84)***
	(5.57)***	(8.22)***	(4.74)***	(7.68)***
GDP^2	-274.244	-164.918	-117.934	-209.157
	(5.17)***	(8.21)***	(4.78)***	(7.79)***
	(5.48)***	(8.16)***	(4.68)***	(7.61)***
GDP^3	9.003	5.464	3.879	6.937
	(5.09)***	(8.14)***	(4.71)***	(7.73)***
	(5.39)***	(8.10)***	(4.61)***	(7.53)***
LEFTC	.004	.002	.001	.001
	(1.88)*	(2.59)***	(1.44)	(1.42)
	(2.03)**	(2.83)***	(1.54)	(1.44)
LEFTS	-.011	-.005	-.002	-.004
	(2.83)***	(3.69)***	(1.72)*	(2.04)**
	(3.29)***	(4.25)***	(1.87)*	(2.16)**
LEFTL	-.056	-.012	-.006	-.021
	(4.45)***	(2.59)***	(3.52)***	(3.32)***
	(4.11)***	(2.81)***	(3.63)***	(3.34)***
Observations	160	160	160	160
R^2 within	.66	.60	.67	.56
R^2 between	.59	.07	.03	.01
R^2 overall	.60	.10	.05	.03

Note: Absolute t values are included in parentheses.

* Significant at 10% level.

** Significant at 5% level.

*** Significant at 1% level.

Table 4: Results for pollution levels with SOCX.

not change a lot, it certainly does so when SOCX is a part of the empirical examination. The numbers listed in Table 5 show that an inclusion of the interaction term provides a change in the way redistribution is connected to pollution.

The inclusion renders all estimated coefficients of SOCX insignificant, despite their expected negative sign. In turn, INQ becomes significantly negative throughout, suggesting that only in the countries with high initial inequality, i.e. all countries in the sample except Belgium, Netherlands, Spain and United Kingdom, higher public spending significantly contributed

	SOx	NOx	CO	VOC
SOCX	-.035	-.003	-.012	-.001
	(1.61)	(.36)	(1.18)	(.07)
	(1.62)	(.32)	(1.01)	(.06)
GDP	2770.991	1653.418	1187.413	2094.125
	(5.37)***	(8.60)***	(5.04)***	(8.20)***
	(5.96)***	(8.59)***	(4.92)***	(8.18)***
GDP^2	-273.369	-164.500	-117.412	-208.566
	(5.29)***	(8.54)***	(4.97)***	(8.14)***
	(5.87)***	(8.54)***	(4.86)***	(8.10)***
GDP^3	8.975	5.451	3.863	6.918
	(5.20)***	(8.47)***	(4.89)***	(8.09)***
	(5.77)***	(8.48)***	(4.79)***	(8.01)***
LEFTC	.003	.002	.001	.001
	(1.48)	(2.12)**	(.93)	(.89)
	(1.53)	(2.12)**	(.92)	(.81)
LEFTS	-.009	-.005	-.002	-.003
	(2.46)**	(3.30)***	(1.26)	(1.57)
	(2.74)***	(3.48)***	(1.28)	(1.49)
LEFTL	-.054	-.011	-.020	-.020
	(4.39)***	(2.50)**	(3.47)***	(3.27)***
	(3.96)***	(2.60)***	(3.26)***	(3.07)***
INQ	-.064	-.095	-.038	.043
	(2.81)***	(3.60)***	(3.66)***	(3.83)***
	(2.78)***	(3.31)***	(3.15)***	(3.36)***
Observations	160	160	160	160
R^2 within	.66	.64	.70	.61
R^2 between	.59	.06	.01	.05
R^2 overall	.60	.07	.00	.02

Note: Absolute t values are included in parentheses.

* Significant at 10% level.

** Significant at 5% level.

*** Significant at 1% level.

Table 5: Results for pollution levels with SOCX and INQ.

to emission reductions. Perhaps, high initial inequality combined with sustained redistribution may lead to lower pollution levels over time, which is one of the theoretically predicted scenarios from Drosdowski (2006), where the pollution level decreases over time for a certain degree of wealth bias (power inequality between the political regime and the median voter) and a relatively low level of environmental preferences. There are, however, nu-

merous caveats concerning this particular result. First of all, the theoretical model has an overlapping generation structure, with time-periods of approximately 25 years, whereas our data encompasses ten years, which does not allow to adequately evaluate the theoretically predicted changes over time. Furthermore, our initial Ginis have been chosen somewhat arbitrarily, with respect to the year of observation (1980 in most cases) and the division in high and low inequality. Finally, the Ginis from Deininger and Squire (1996) represent initial after-tax inequality, whereas a theoretically valid measure should be pre-tax inequality. Despite these difficulties, the main result appears to hold, namely that there is a significant and negative correlation between a redistributive measure and pollution.
The other control variables become again slightly less significant due to the addition of INQ, without any loss of important qualitative properties. Only left cabinet strength becomes insignificant in case of SOx, whereas left seat percentage loses significance for CO and VOC.

6 Robustness Checks

In order to examine the robustness of the reported results we have performed a variety of additional tests. The first one, using RED, has been made without the logarithmic transformation of variables, i.e. the variables in question are in levels instead of logs. The estimated coefficients of RED still retain their statistical significance in all cases. GDP per capita still follows the same pattern as previously, although in case of SOx income becomes insignificant after the inclusion of INQ. Political variables again display low statistical significance. However, the signs are much more inconsistent compared with the logarithmic specifications. INQ is never significant and the estimated coefficients have inconsistent signs. It appears to be safe to say that the logarithmic model fits the data better. Replacing RED with SOCX yields similar results with respect to the impact of redistribution on pollution. Without using INQ in the regressions, SOCX is always significantly negative, whereas its inclusion makes SOCX statistically insignificant for NOx and VOC. Income is always significant and enters with expected signs. This time, political variables have in all cases the expected signs. Their coefficients are significant with the exception of the CO-regression, where only left-libertarian seats percentage has statistical impact. INQ is insignificant, and the corresponding coefficients are mostly negative, except for SOx. Furthermore, we have performed tests including only the most intriguing and pervasive political variable, which is LEFTL. The results are very similar to those obtained by using all three political variables.

We tried to incorporate a measure of democratization in our analysis, as well. This endeavor proved difficult to tackle, since all countries from which data is available are accomplished democracies, and there would be no variation when conventional democracy measures were used. Nevertheless, we found a variable representing the length of democratic experience. It is taken from the Polity IV data set, covering democratic developments in a large selection of countries (Marshall and Jaggers 2002). The data set provides an indicator for democracy on a scale from 0 to 10, as well as autocracy (-10 to 0). All countries in our sample have the highest democracy score. The variable (DUR) corresponds to "durable" from Polity IV, and denotes the number of years in which no substantial regime change, equal to a 3-point change in the Polity-score has occurred. Testing equation (1) reveals no substantial changes with respect to the basic specification. All coefficients retain their signs and, by and large, their significance. The main exception is the coefficient for RED in both VOC-equations, which becomes statistically insignificant. DUR itself is barely significant in the SOx-equation. Otherwise it is not, and the signs are mixed. When SOCX is used as a proxy for redistribution, some differences emerge. Without INQ, left-party strength variables keep their statistical significance, and SOCX loses its significance in case of VOC. However, in the regressions containing INQ, SOCX is always insignificant and its signs are mixed. Additionally, the interaction term is insignificant for SOx. The variable chosen to account for democratic experience is highly significant with a negative sign, contrary to the cases where RED is involved, which may, at first glance, support the hypothesis that democratization is good for the environment directly, if one assumed that sustained democratic order went hand-in-hand with democratic progress. DUR, which is a very crude measure, is a problematic variable. Since it increases by one in each year for all countries, it is exactly equivalent to a time trend in the fixed-effects specification. The results with respect to redistribution remain nevertheless strong.

We have also run regressions using year-dummies, which has been only possible for SOCX due to the fact that the limited number of observations for

RED does not allow to test this alternative specification. Compared to the reference year 1990, the coefficients for the dummies indicate a negative time trend, which is a typical pattern, usually interpreted as exogenous technological progress. SOCX is now significant in all regressions without INQ, as well as one regression with the interaction term (for SOx). LEFTL is the only political variable that is always statistically significant and entering with the right sign. LEFTS displays the same characteristics only in the NOx-equation. INQ is significantly negative in the regressions for VOC and CO.
Overall, the robustness checks support the main results obtained in the previous section. We believe that the conclusions we draw there can be maintained.

7 Conclusions

The empirical investigation undertaken in this paper allows to conclude that redistribution has had a significant impact on air pollution in a large sample of Western European countries during the previous decade. Both proxies for redistribution, i.e. inequality reduction measured as a difference between pre-tax and post-tax Gini coefficients and the level of total public social spending are positively correlated with emission reductions. These reductions are substantial for the four analyzed air pollutants. A one unit increase in the first measure is associated with 7.8 % less sulphur oxides, 3.1 % less nitrogen oxides, 4.6 % less carbon monoxide and 3.9 % less volatile organic compounds. Similarly, the employment of the alternative proxy yields reductions of 8.9, 2.9, 4.4 and 3.7 %, respectively, when public social expenditure increases by one percent. The results fulfill theoretical expectations that increasing progressivity of redistribution for a given level of environmental preferences can diminish pollution by reallocating resources from polluting activities to abatement. While the estimated impact of redistribution appears to be strong, one has to be extremely careful with the interpretation of redistributive measures as a potential panacea for environmental woes. For one thing, the sample size used in the analysis is very small. Moreover, we have only studied a small part of a large environmental problem, which is air pollution. Increased redistribution in OECD countries since the middle of the 1980s can probably be attributed to upward inequality trends during this period (see Tanninen and Tuomala 2001), but decreasing pollution flows may have more to do with changing social norms or technological improvements. Both developments could well coincide and be unrelated to each other. However, obtaining our results, we have controlled for income, which incorporates the effects of structural change and technological progress on the environment, as well as for the strength of green parties, widely recognized as the main bearer of post-materialist thought. We have not been able to analyze to which extent democratization, historically connected to increasing redistribution, could be responsible for better environmental quality, since the countries in our sample do not provide any palpable variation in democracy. Data limitations prevent us from studying the relationship between power inequality and pollution in developing countries. There is hope, as always, that future research might be equipped with better quality data encompassing more countries and larger time-horizons.

Appendix

A1. The table below shows the calculated inequality reductions via redistribution (RED). Gini-MI denotes the market income inequality, while Gini-DPI is the disposable income inequality.

Country	Year	Gini-MI	Gini-DPI	RED
Austria	1994	44.3	28.0	16.3
Austria	1997	43.3	26.6	16.7
Belgium	1992	45.2	22.4	22.8
Belgium	1997	48.3	25.0	23.3
Denmark	1992	42.7	23.6	19.1
Finland	1991	33.4	21.0	12.4
Finland	1995	38.8	21.7	17.1
France	1994	49.0	28.8	20.2
Germany	1994	44.6	27.3	17.3
Greece	1995	46.2	34.9	11.3
Ireland	1994	50.2	33.3	16.9
Ireland	1995	49.2	33.6	15.6
Ireland	1996	48.5	35.5	13.0
Italy	1991	39.7	29.0	10.7
Italy	1993	45.2	33.9	11.3
Italy	1995	45.5	33.8	11.7
Italy	1998	46.7	34.6	12.1
Netherlands	1991	41.0	26.6	14.4
Netherlands	1994	42.3	25.7	16.6
Netherlands	1999	39.4	25.6	13.8
Norway	1991	37.7	23.1	14.6
Norway	1995	40.3	23.8	16.5
Spain	1990	42.6	30.3	12.3
Spain	1995	50.5	35.3	15.2
Sweden	1992	46.7	22.9	23.8
Sweden	1995	46.6	22.1	24.5
Switzerland	1992	38.4	30.7	7.7
United Kingdom	1991	48.1	33.6	14.5
United Kingdom	1994	50.6	33.9	16.7
United Kingdom	1995	50.8	34.4	16.4
United Kingdom	1999	50.3	34.2	16.1

Table 6: Redistribution measured by RED.

A2. Information on the analyzed air pollutants.

SOx	
Sources:	combustion of fuels containing sulphur in power stations, industrial sites, household and commercial sources, transportation
Impacts:	respiratory diseases, contribution to acid rain
NOx	
Sources:	fuel combustion in transportation, power plants, industry and households
Impacts:	smog, respiratory diseases, ozone production, acid rain
CO	
Sources:	carbon combustion in industrial processes, motor vehicles and coal stoves
Impacts:	oxygen starvation in the body, contributes to ozone formation
VOC	
Sources:	vapors from paints, solvents or fuels
Impacts:	cancer, leukaemia, ozone formation

Source: WHO (2003).

Table 7: Air pollutants used in the study.

A3. Initial inequality measured by Gini index:

Austria (1981): 31.4, Belgium (1979): 28.3, Denmark (1981): 31.0, Finland (1980): 30.9, France (1979): 34.9, Germany (1981): 30.6, Greece (1981): 33.3, Ireland (1980): 35.7, Italy (1980): 34.3, Netherlands (1979): 28.1, Norway (1979): 31.2, Portugal (1980): 36.8, Spain (1980): 26.8, Sweden (1980): 32.4, Switzerland (1982): 32.9 and United Kingdom (1979): 24.4

A4. Summary statistics are given in Tables 8 and 9.

Variable	Mean	SD	Min	Max
ln(SOx)	3.168	.836	1.565	4.411
ln(NOx)	3.659	.255	2.854	4.166
ln(CO)	4.787	.316	3.952	5.252
ln(VOC)	3.659	.255	3.071	4.325
RED	15.835	4.031	7.7	24.5
ln(GDP)	9.996	.163	9.575	10.323
$(\ln(GDP))^2$	99.95	3.238	91.69	106.565
$(\ln(GDP))^3$	999.63	48.321	877.973	1100.073
LEFTC	43.419	36.442	0	100
LEFTS	24.745	19.169	0	63
LEFTL	3.658	3.319	0	10.3
INQ	9.961	8.265	0	24.5

Number of Observations = 31

Table 8: Summary Statistics for RED

Variable	Mean	SD	Min	Max
ln(SOx)	3.115	.919	.730	4.436
ln(NOx)	3.636	.33	2.452	4.193
ln(CO)	4.808	.339	3.846	5.4
ln(VOC)	3.666	.262	2.963	4.325
SOCX	25.11	4.602	13.901	36.772
ln(GDP)	9.987	.210	9.509	10.45
$(\ln(GDP))^2$	99.78	4.173	90.42	109.204
$(\ln(GDP))^3$	997.353	62.159	859.803	1141.181
LEFTC	42.909	36.158	0	100
LEFTS	24.591	19.186	0	63
LEFTL	3.532	3.181	0	10.3
INQ	19.042	11.833	0	36.772

Number of Observations = 160

Table 9: Summary Statistics for SOCX

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