Departament d'Economia Aplicada

DOCUMENT DE TREBALL

Inequality in CO2 emissions across countries and its relationship with income inequality: a distributive

Emilio Padilla / Alfredo Serrano

05.03

Universitat Autònoma de Barcelona

Facultat de Ciències Econòmiques i Empresarials

Aquest document pertany al Departament d'Economia Aplicada.

Data de publicació : **Gener 2005**

Departament d'Economia Aplicada
Edifici B
Campus de Bellaterra
08193 Bellaterra

Telèfon: (93) 581 1680
Fax:(93) 581 2292
E-mail: d.econ.aplicada@uab.es
http://www.ecap.uab.es

Inequality in CO_2 emissions across countries and its relationship with income inequality: a distributive approach

Emilio Padilla* and Alfredo Serrano**

*(Corresponding author)

Departament d'Economia Aplicada, Universitat Autònoma de Barcelona

Edifici B, Campus de Bellaterra, 08193 Bellaterra (Spain)

Fax: 00 34 93 581 22 92 Tel.: 00 34 93 581 34 15

Email: emilio.padilla@uab.es

** Departament d'Economia Aplicada, Universitat Autònoma de Barcelona

Edifici B, Campus de Bellaterra, 08193 Bellaterra (Spain)

Email: alfredo.serrano@uab.es

Abstract

This paper analyses the inequality in CO_2 emissions across countries (and groups of countries) and the relationship of this inequality with income inequality across countries for the period (1971-1999). The research employs the tools that are usually applied in income distribution analysis. The methodology used here gives qualitative and quantitative information on some of the features of the inequalities across countries that are considered most relevant for the design and discussion of policies aimed at mitigating climate change. The paper studies the relationship between CO_2 emissions and GDP and shows that income inequality across countries has been followed by an important inequality in the distribution of emissions. This inequality has diminished mildly, although the inequality in emissions across countries ordered in the increasing value of income (inequality between rich and poor countries) has diminished less than the "simple" inequality in emissions. Lastly, the paper shows that the inequality in CO_2 emissions is mostly explained by the inequality between groups with different per capita income level. The importance of the inequality within groups of similar per capita income is much lower and has diminished during the period, especially in the low-middle income group.

Key words: environmental Kuznets curve, inequality across countries, CO_2 emissions.

Acknowledgements

Financial support from projects BEC2003-01831 and 2001SGR160 is acknowledged.

Inequality in CO_2 emissions across countries

1. Introduction

The inequality in the distribution of CO_2 emissions across countries is one of the most relevant issues for the design of global climate policies. While rich countries fear the dangers to economic growth of limiting their emissions, poor countries argue the great inequality in current and past emissions for not limiting their development possibilities with mitigation policies. The different relative responsibilities of the inhabitants of different countries and groups of countries and the problems generated by this inequality constitute fundamental features to be taken into account in the negotiations among countries on the actions for mitigating the emission of greenhouse gases. Among the studies that analyse this inequality are those in the IPCC (1996) report and the research of Heil and Wodon (1997). The latter introduces some measures taken from income distribution analysis, such as the Gini index, for measuring the inequality across countries in the emissions of the major greenhouse gas.[1]

This research applies the tools of income distribution analysis to the study of the inequality in CO_2 emissions across countries. It analyses the relationship between this inequality and income inequality across different countries and across groups of countries in the three last decades.[2] The non-parametric estimation techniques enable estimation of the expected relationship between per capita income and CO_2 emissions per capita, indicating the effect of income inequality on emissions inequality. Concentration indexes and Gini indexes of emissions measure the inequality in emissions across countries ranked in the distribution of income (inequality between rich and poor countries) and the "simple" inequality in emissions respectively. These measures provide greater information than the studies that only use the "simple" inequality in emissions, because international discussions

and agreements focus on the distribution of emissions between rich and poor countries. Furthermore, the decomposition of the inequality in CO_2 emissions in two components—the inequality between groups of countries with different per capita income level, and the inequality within each group of countries with similar per capita income level—provides a better identification of the characteristics of CO_2 inequality. The decomposition also indicates whether per capita GDP is an explanatory factor of the inequality in emissions across countries. That is to say, it identifies whether the reduction in the inequality in emissions experienced it is due to a reduction in the inequality between rich and poor countries or whether it is instead due to a greater equality between the countries with a similar income level. The paper represents an innovative methodological contribution as it adapts to energy analysis some analytical techniques that are quite prestigious in the analysis of income distribution.

The paper is organised as follows: Section 2 employs the non-parametric estimation techniques for estimating the expected relationship between per capita CO_2 emissions and per capita income of the different countries. Section 3 analyses the degree of inequality in CO_2 emissions across different countries ordered in the increasing value of per capita income through the concentration curves of emissions and compares them with income inequality through the Kakwani index for different years. Next, it compares this concentration of CO_2 emissions with the "single" inequality in emissions. Section 4 classifies the countries into four income groups and decomposes the inequality into within- and between-group components. Finally, the last section comments the main results of the research.

2. Analysis of the relationship between CO_2 emissions and per capita income of the different countries through non-parametric estimation

In this section, the expected relationship between per capita CO_2 emissions and per capita income of the different countries is estimated through non-parametric estimation techniques (Silverman, 1986). This methodological tool has grown significantly in the last fifteen years. Contrary to conventional estimation methods, however, it does not assume any predetermined functional form. The methodology gives a clear graphical indication of the shape taken by the relationship between the two variables.[3]

The study of the relationship between environmental pressure indicators —such as emissions—and income levels has generated multiple theories and no small amount of empirical research. One hypothesis that has generated great controversy in the last decade is the hypothesis of the environmental Kuznets curve, according to which the environmental problem increases as per capita income increases up to a point from which higher per capita income would lead to lower environmental pressure due to factors such as greater environmental concern, the development of more environmental-friendly technologies, or the change in production composition as a society increases its income level and demands more services. Several studies have contrasted this hypothesis on different pollutants with different results (revisions in Ekins, 1997; Stern, 1998; or Stern et al., 1996), the evidence generally being to the contrary for the case of CO_2 emissions (see e.g. Roca et al, 2001).

Figure 1 shows the non-parametric estimation of the relationship between per capita CO_2 emissions and per capita GDP, taking all the observations of the panel of countries for the considered years. This analysis could be considered analogous to the parametric estimation with panel data that is usually computed in the literature on the environmental

Kuznets curve, although here the resulting expected relationship does not impose any functional form.

[FIGURE 1 ABOUT HERE]

The graphic shows a relationship that, at first sight, could be consistent with the environmental Kuznets curve hypothesis, which posits that from a certain income level there is a de-linking between economic growth and environmental pressure. It can be observed that there is a point over $32 (1995 dollars in ppp) from which it seems that greater income would be accompanied by lower environmental pressures.

However, the most of the human population is concentrated in the section of the curve where there is a positive relationship between greater income and greater emissions. This is shown by the population density function of per capita GDP (Figure 2), which reveals that most countries are concentrated under $10 per capita. Therefore, in the hypothetical case that the countries followed the same behaviour as that shown by the expected relationship computed, economic growth would imply greater emissions for most countries —unless there were adequate environmental policies changing the relationship between emissions and income. That is to say, even in the case that there were a mechanism such as the one suggested by the environmental Kuznets curve, according to which there is a de-linking between income growth and emissions, before the de-linking point was achieved most of the world population would have increased their emissions by an enormous amount, thereby causing an environmental degradation with catastrophic

consequences. This result is consistent with the empirical evidence shown by other researches (e.g. Selden and Song, 1994; or Stern et al., 1996).

[FIGURE 2 ABOUT HERE]

The estimation is the result of considering the data of all the countries throughout the period. The usual assumption of conventional panel data analysis is that, while for each country the level of emissions for each per capita income level can be different, the income elasticity of emissions is the same for all the countries for each income level (Stern, 2003, p. 4), so the inflexion point would be the same for the different countries. However, this is a problematic assumption (Dijkgraaf and Vollebergh, 1998). It is too restrictive to assume that countries with very different economic, geographic, and cultural structures would follow the same behavioural pattern. Therefore, the countries could not be assumed to behave over time following the relationship estimated for the panel of countries, and it would be necessary to undertake an analysis for individual countries and groups of countries (Roca et al. 2001). Furthermore, it is possible that some rich countries would have achieved some reduction in their emissions —or limited their growth— at the expense of externalising environmental costs by moving the polluting industries and the extraction of resources and energy to poorer countries (Arrow et al., 1995 and Stern et al., 1996). Therefore, it is not possible for poor countries to reproduce this behaviour in the future.

Next, the non-parametric relationship between per capita CO_2 and per capita GDP is analysed for four years of the period. This makes it possible to observe whether there have been changes in this relationship.

[FIGURE 3 ABOUT HERE]

Figure 3 shows how the relationship between per capita GDP and per capita emissions changes throughout the period. The curves show that for the poorest countries, the relationship between emissions and per capita GDP is always positive for all the years. In the cases of the years 1971 and 1981, there is a point (around $17 in 1971 and $22 in 1891) from which for an income interval, the level of per capita emissions is lower for countries with higher per capita income. However, for a greater level of per capita income there is a new inflexion point from which emissions increase with per capita income of countries. As for the other years (1991 and 1999), emissions always grow with income. Therefore, these data do not seem to show that there is a de-linking between income and emissions as posited by the environmental Kuznets curve.

Furthermore, the density function of the population corresponding to the different per capita GDP of the countries (Figure 4) shows that the greater part of countries, and of world population, is concentrated in all the years in the section of the curves in which there is a positive relationship between per capita GDP and emissions.[4]

[FIGURE 4 ABOUT HERE]

The analysis of this section shows that greater per capita income is related to greater per capita emissions for most countries; so greater inequalities in international income would also be associated with greater inequalities in emissions across countries. Next, the

inequality in emissions across countries and its relationship with the income inequality is analysed.

3. The inequality in CO_2 distribution across countries and its relationship to income distribution

3.1. The inequality in CO_2 distribution across countries ranked in the distribution of income and the "regressivity" of the distribution of CO_2 emissions

First, this section analyses the inequality in the distribution of emissions across countries ranked in the distribution of income during the period. That is to say, the degree of concentration in the distribution of emissions across countries ordered in increasing value of per capita income. With this object, the concentration index, also called pseudo-Gini, of CO_2 emissions has been computed for each year. This index is computed through the concentration curves of emissions ? curves that show the percentage of emissions that concentrate different shares of population, ordered in increasing value of per capita income (and not according to per capita emissions). Therefore, the concentration index or pseudo-Gini of emissions shows the inequality in emissions between the populations in rich and poor countries. That is to say, it shows to what degree the inhabitants of rich countries pollute more than those of poor countries.

Next, the inequality in emissions distribution across countries ranked in the distribution of income is compared with the inequality in income distribution. For this, the concentration index of emissions is compared with the Gini index of income. The Gini index shows the inequality in income distribution. This index is computed through the Lorenz curve ? the curve that shows the degree of income inequality, i.e., the percentage of

income received by different percentages of population, ordered in increasing value of per capita income. The Kakwani index computes the extent to which the inequality in the distribution of emissions between rich and poor countries is greater than the inequality in the distribution of income. In other words, the Kakwani index computes the level of "progressivity" or "regressivity" of the distribution of emissions. This index is equal to the concentration index of emissions or pseudo-Gini minus the Gini index.[5]

[TABLE 1 ABOUT HERE]

[FIGURE 5 ABOUT HERE]

Table 1 and Figure 5 show the evolution throughout the studied period of the Gini index of income distribution and the concentration index or pGini of emissions. It should be emphasised that both indexes diminished, so both inequalities diminished over time. Furthermore, the indexes show that the difference between rich and poor countries was even greater in CO_2 emissions distribution than in income distribution both at the beginning and at the end of the period. However, the difference between both indexes diminished strongly between 1971 and 1986, and during various years the distribution of emissions was not "regressive", in the sense that the concentration of emissions in the populations of rich countries was lower than the concentration of income. This stage coincides with the economic crisis and the increase in oil prices. However, from 1986 there is an important change in trend, increasing the "regressivity" in the distribution of emissions. This change coincides with a strong decrease in oil prices (jointly with a lower value of the dollar) and with a new phase of strong economic growth in rich countries. Therefore, although the

greater inequality in the distribution of emissions with respect to income distribution has diminished, it has not disappeared. This can be clearly observed in Figure 6, which shows the evolution of the difference between the concentration index and the Gini index expressed through the Kakwani index.

[FIGURE 6 ABOUT HERE]

In order to observe what has happened for the different per capita income levels it is of great utility to examine the graphical analysis of the concentration curves of CO_2 emissions and the Lorenz curve of income distribution. The curves for the beginning and the end of the period are shown.

[FIGURE 7 ABOUT HERE]

[FIGURE 8 ABOUT HERE]

For 1971 there is an inequality in emissions across countries of different income level greater than the inequality in income distribution, except for the richest 5% of the population However, this difference has diminished strongly, as shown by the curves of 1999. The grap shows that most of the reduction in the “regressivity” occurs across the countries that are placed within percentiles 70 to 85, the median percentiles also being important. The inequality does not change much in the lower percentiles, and it even increases considerably within percentiles 85 and 100. This could be explained by the strong increase in emissions experienced by the United States.

3.2. Concentration versus inequality in CO_2 emissions

Next, an alternative index to the concentration index of CO_2 emissions is computed: the Gini of CO_2 emissions.[6] This index shows the "simple" inequality in CO_2 emissions (without ranking the countries according to their per capita income). From the point of view of this paper, concentration indexes give information that is more relevant for the discussions over distributive issues than the "simple" inequality in emissions, because these discussions are focussed in the distribution of emissions between rich and poor countries. However, both indexes complement each other, and provide information on different aspects of the inequality in emissions to be considered in the negotiations among countries as well as in the normative analysis on the distribution of emissions.

In Table 2 and Figures 10 and 11 the Gini index of emissions can be compared with the pseudo-Gini index of emissions previously computed. The level of "simple" inequality is also computed through the inequality index of Theil. This index gives information equivalent to the Gini index of emissions, but with some advantages with respect to the decomposition possibilities that are developed in Section 4.

[*TABLE 2 ABOUT HERE]*

[FIGURE 9 ABOUT HERE]

[FIGURE 10 ABOUT HERE]

The evolution of the Gini and Theil indexes shows a reduction in the inequality in the distribution of emissions, a result not unlike the ones of other studies (e.g., Heil and Wodon, 1997). However, the reduction in the inequality shown by these indexes is much plainer and more constant than the one shown when considering the concentration index of emissions or pseudo-Gini (see table 3 and figure 9) in subsection 3.1. The degree of concentration of emissions in rich countries has diminished to a lesser extent than the "simple" inequality in emissions. This shows that, although the "simple" inequality in emissions has diminished, the difference between rich and poor countries has not diminished to the same extent. Therefore, an analysis that was only based on the "simple" inequality in emissions could lead to different results.

In order to analyse the characteristics of the evolution of the inequality observed in the present section it is especially interesting to decompose this inequality for different groups of countries, and that is what is undertaken in the next section.

4. Decomposition of CO_2 inequality into between group and within group inequality for low, low middle, upper middle, and high income groups

This section decomposes the inequality in the distribution of CO_2 emissions into the inequality between groups of countries and the inequality within these groups. This allows studying whether the reduction in the inequality in emissions is due to a reduction in the inequality between poor and rich countries or whether, instead, the change is due to an equalization of the countries with similar income levels. This would clarify the importance of income inequality for explaining the inequality in CO_2 emissions across countries over the period. The groups defined by the 2002 World Development Report of the World Bank

have been employed for the decomposition. These are groups which classify the countries according to their per capita GDP in year 2000 as low income, low middle income, upper middle income, and high income. The Theil index has been used for the decomposition. This index has some advantages with respect to the decomposition of Lerman and Yitzhaki (1985) of the Gini index.[7] The Theil index is a decomposable index of inequality. This index explains the total amount of inequality in a distribution by the extent of inequality found within groups and between them. The Lerman and Yitzhaki decomposition of the Gini index only identifies the inequality within groups, but it does not identify the inequality between different groups, because there is a percentage which is not decomposed (residual error) (Lambert, 1993).

As can be observed in figure 11, the decomposition of the Theil index shows that the greater part of the inequality in emissions corresponds to the between-group component (from 2/3 at the beginning of the period to 4/5 at the end). As for the contribution of inequality within the groups, this is much lower, and it is mostly concentrated in the groups of low-middle income and high income, as can be seen in figure 12. Although both inequalities diminished throughout the studied period, the reduction in the within-group inequality is much more important in relative and absolute terms than the reduction in the between-group inequality (see table 3).

[FIGURE 11 ABOUT HERE]

As for the evolution over time, the share of the between-group component of inequality experiences a strong increase during the period; it changes from 66.04% to 77.34%, while the inequality within groups diminishes from 33.96% to 22.66%.

[FIGURE 12 ABOUT HERE]

It should be emphasized that the group of low income is the only one that experiences an increase in total inequality contribution, changing from 0.0034 to 0.0135 and increasing from 0.41% to 2.2% its share on total inequality. This inequality diminishes in the rest of groups, especially in the group of low-middle income, which changes from 0.1575 to 0.0521 (from 18.79% to 8.48% of total inequality). This case can be explained by the cut-back in emissions in the ex-USSR (which emitted more CO_2 per unit of GDP than the other countries), together with an important increase in China and other countries of the group. Therefore, the reduction in the inequality in CO_2 emissions is due to the reduction of the within-group inequality, explained to a great extent by the reduction of inequality within the low-middle income group, while the reduction between the different income groups is much lower. That is to say, the inequality between rich and poor countries is more persistent than the inequality within income groups. Income inequality maintains its capacity for explaining the difference in emissions across countries, and the correlation between emissions and the classification according to income holds throughout the period.[8] This result gives strength to the idea that the objectives of reduction focused on rich countries would be efficient in reducing global inequality.[9] The reduction in inequality within income groups would have a more limited impact, although it is still relevant for groups 2 (low middle income) and 4 (high income).

[TABLE 3 ABOUT HERE]

5. Conclusions

This paper has employed the methodologies usually employed in the analysis of income inequality for the study of the inequality in the distribution of CO_2 emission and its relationship with income inequality. This approach provides relevant quantitative and qualitative information about some of the major distributive issues of climate change.

The application of non-parametric estimation techniques shows that for an overwhelming majority of countries, higher per capita income should be expected to be followed by higher emissions. The present paper has highlighted the need to apply appropriate environmental measures in order to change the relationship between per capita GDP and emissions in order to avoid serious consequences on the environment.

As for the evolution of the inequality in CO_2 emissions, this diminishes over time. This inequality is higher than income inequality across countries. However, the reduction in emissions inequality is much lower when the inequality in emissions between rich and poor countries (emissions concentration) is considered than when the "simple" inequality in emissions is considered. The results show that although the "simple" inequality in CO_2 emissions has diminished, the inequality between what the inhabitants of rich and poor countries emit has diminished to a lesser extent.

The inequality during the period is explained mainly by the inequality between the different groups of countries classified according to their per capita income. The reduction in inequality is mainly due to the reduction in the inequality within some groups, especially within the low middle income group. The cause is the reduction in emissions in the former-USSR and the increase experienced by China and other countries of the group. The factor of income inequality maintains its capacity for explaining the inequality in emissions across countries throughout the studied period.

Notes

[1] Heil and Wodon (2000) also undertake a distributive analysis on projections of future emissions.

[2] The data employed in this analysis are taken from the International Energy Agency (IEA) and comprise the period 1970-1999. These data comprise the CO_2 emissions coming from the combustion of fossil fuels of 113 countries (in few cases the data consider groups of small countries such as other Asia, other Latin America or other Africa).

[3] This would facilitate the work if a conventional parametric estimation were undertaken (see e.g. Taskin and Zaim, 2002), because it shows graphically the functional relationship that best approaches the relationship between the variables, without following a trial-and-error process taking into account the different possibilities (cubic income, square income, etc…).

[4] In fact, the shape of the non-parametric estimation in the section over $32 is not very relevant, as it is much conditioned by scarce extreme observations, corresponding to the United Arab Emirates, Luxembourg, Kuwait, and Qatar. The highest point in the curve of 1981 is due to the value of Qatar. The estimation takes this shape because it is the only observation for 1981 with this level of per capita GDP.

[5] In order to measure inequality across countries, when computing the indexes, the inequality within individual countries was ignored, which is the usual procedure in the analysis of interregional inequality. Of course, the observations are weighted according to the populations of countries, so both the curves shown in the previous section and the indexes of inequality presented in this section are more affected by what happens in a country with higher population than by what happens in a country with lower population.

[6] Heil and Wodon (1997) compute this index for the period 1960-1990.

[7] Heil and Wodon (1997) use the Lerman and Yitzhaki (1985) decomposition in their work on emissions inequality. In the field of energy economics, Alcántara and Duro (2004) use the Theil index for analysing the inequality in energy intensity across OCDE countries.

[8] This result also explains the divergence between the Theil and concentration indexes previously computed: the concentration index considers the extent to which the emissions are concentrated in rich countries with respect to poor countries while the Theil or Gini indexes show “simple” inequality.

[9] Annex II countries of the United Nations Framework Convention on Climate Change, which belong to the high income group, are the countries which concentrate the mitigation efforts of the Kyoto Protocol.

References

Alcántara, V., Duro, J.A., 2004. Inequality of energy intensities across OECD countries: a note. Energy Policy 32, 1257-1260.

Arrow, K., Boling, B., Costanza, R., Dasgupta, P., Folke, C., Holling, S., Jansson, B-O, Levin, S., Mäler, K.-G., Perrings, C., Pimentel, D., 1995. Economic growth, carrying capacity and the environment. Science 268, 520-521.

Dijkgraaf, E., Vollebergh, H.R.J., 1998. Environment Kuznets revisited. Time-series versus panel estimation: The CO_2 case. Research memorandum 9806, OCFEB, Erasmus University, Rotterdam.

Ekins, P., 1997. The Kuznets curve for the environment and economic growth: examining the evidence. Environment and Planning A 29, 805-830.

Heil, M.T., Wodon, Q.T., 1997. Inequality in CO_2 emissions between poor and rich countries. Journal of Environment and Development 6, 426-452.

Heil, M.T., Wodon, Q.T., 2000. Future inequality in CO_2 emissions and the Impact of abatement proposals. Environmental and Resource Economics 17, 163-181.

Intergovernmental Panel on Climate Change (IPCC), 1996. Climate Change 1995. Economic and social Dimensions of Climate Change. Contribution of Working Group III to the Second Assessment Report of the IPCC. Cambridge University Press, Cambridge.

International Energy Agency, 2001. CO_2 Emissions from fuel combustion, 1971-1999. 2001 Edition. International Energy Agency, Paris.

Lambert, P.J., 1993. The Distribution and Redistribution of Income. A Mathematical Analysis. Manchester University Press, Manchester.

Lerman, R., Yitzhaki, S., 1989. Improving the accuracy of estimates of Gini coefficients. Journal of Econometrics 42, 43-47.

Roca, J., Padilla, E, Farré, M., Galletto, V., 2001. Economic growth and atmospheric pollution in Spain: discussing the environmental Kuznets curve hypothesis. Ecological Economics 39, 85-99.

Selden, T.M., Song, D., 1994. Environmental quality and development: is there a Kuznets curve for air pollution estimates? Journal of Environmental Economics and Management 27, 147-162.

Silverman, B.W., 1986. Density Estimation for Statistics and Data Analysis. Chapman & Hall, London.

Smith, K., 1991. Allocating Responsibility for Global Warming: The Natural Debt Index. Ambio 20, 95-96.

Stern, D.I., 1998. Progress on the environmental Kuznets curve? Environment and Development Economics 3, 173-196.

Stern, D.I., 2003. The environmental Kuznets Curve. Internet Encyclopedia of Ecological Economics, International Society for Ecological Economics, available in: http://www.ecologicaleconomics.org/publica/encyc.htm

Stern, D.J., Common, M.S., Barbier, E.B., 1996. Economic growth, trade and the environment: implications for the environmental Kuznets curve. World Development 24, 1151-1160.

Taskin, F., Zaim, O., 2000. Searching for a Kuznets curve in environmental efficiency using kernel estimation. Economics Letters 68, 217-223.

World Bank, 2002. World Development Report. World Bank, Washington, D.C.

Appendix 1

Groups of countries according to their per capita income

Group 1 Low income	Group 2 Low middle income	Group 3 Upper middle income	Group 4 High income
Angola	Albania	Argentina	Australia
Bangladesh	Algeria	Bahrain	Austria
Benin	Bolivia	Brazil	Belgium
Cameroon	Bulgaria	Chile	Canada
Congo	People's Republic of China	Czech Republic	Chinese Taipei
Democratic Republic of Congo	Colombia	Gabon	Cyprus
Côte d'Ivoire	Costa Rica	Hungary	Denmark
Ethiopia	Cuba	Korea	Finland
Ghana	Dominican Republic	Lebanon	France
Haiti	Ecuador	Libya	Germany
India	Egypt	Malaysia	Greece
Indonesia	El Salvador	Malta	Hong Kong, China
Kenya	Guatemala	Mexico	Iceland
Mozambique	Honduras	Oman	Ireland
Myanmar	Islamic Republic of Iran	Panama	Israel
Nepal	Iraq	Poland	Italy
Nicaragua	Jamaica	Saudi Arabia	Japan
Nigeria	Jordan	Slovak Republic	Kuwait
Pakistan	Morocco	South Africa	Luxembourg
Senegal	Paraguay	Trinidad and Tobago	Netherlands
Sudan	Peru	Uruguay	New Zeeland
United Republic of Tanzania	Philippines	Venezuela	Norway
Togo	Romania		Portugal
Vietnam	Sri Lanka		Qatar
Yemen	Syria		Singapore
Zambia	Thailand		Spain
Zimbabwe	Tunisia		Sweden
Other Africa	Turkey		Switzerland
Other Asia	Ex-USSR		United Arab Emirates
	Ex-Yugoslavia		United Kingdom
			United States
			Other Latin America

Year	GDP Gini	CO_2 Pseudo Gini	Kakwani
1971	0.587116	0.616961	0.029845
1972	0.592437	0.616591	0.024154
1973	0.593927	0.618114	0.024187
1974	0.590733	0.611025	0.020292
1975	0.585972	0.594312	0.008340
1976	0.590836	0.599674	0.008838
1977	0.590375	0.589681	-0.000694
1978	0.590130	0.581595	-0.008535
1979	0.593250	0.580215	-0.013035
1980	0.589725	0.576984	-0.012741
1981	0.588367	0.574118	-0.014249
1982	0.582075	0.563438	-0.018637
1983	0.580283	0.562237	-0.018046
1984	0.579665	0.561615	-0.018050
1985	0.576964	0.558731	-0.018233
1986	0.575789	0.551684	-0.024105
1987	0.573940	0.571819	-0.002121
1988	0.571803	0.572598	0.000795
1989	0.572495	0.570075	-0.002420
1990	0.571949	0.566770	-0.005179
1991	0.569767	0.562909	-0.006858
1992	0.564362	0.556414	-0.007948
1993	0.558148	0.553333	-0.004815
1994	0.554362	0.539542	-0.014820
1995	0.548005	0.528644	-0.019361
1996	0.543818	0.526904	-0.016914
1997	0.542071	0.533359	-0.008712
1998	0.541071	0.545145	0.004074
1999	0.539231	0.549388	0.010157

Table 1. Concentration indexes and Kakwani

Year	GDP Gini	CO_2 Gini	CO_2 Pseudo-Gini	GDP Theil	CO_2 Theil
1971	0.587116	0.672765	0.616961	0.600162	0.838467
1972	0.592437	0.673590	0.616591	0.613321	0.841783
1973	0.593927	0.672830	0.618114	0.618290	0.839183
1974	0.590733	0.667835	0.611025	0.611144	0.823861
1975	0.585972	0.658406	0.594312	0.600038	0.795078
1976	0.590836	0.662418	0.599674	0.610858	0.805893
1977	0.590375	0.657186	0.589681	0.609309	0.791175
1978	0.590130	0.653147	0.581595	0.609046	0.778458
1979	0.593250	0.651300	0.580215	0.618439	0.772518
1980	0.589725	0.647418	0.576984	0.610577	0.760764
1981	0.588367	0.644403	0.574118	0.607129	0.752672
1982	0.582075	0.638086	0.563438	0.594091	0.734145
1983	0.580283	0.635942	0.562237	0.590681	0.728313
1984	0.579665	0.635381	0.561615	0.591776	0.725362
1985	0.576964	0.631625	0.558731	0.588448	0.715945
1986	0.575789	0.626334	0.551684	0.587289	0.701786
1987	0.573940	0.624805	0.571819	0.584983	0.698825
1988	0.571803	0.622707	0.572598	0.583009	0.693962
1989	0.572495	0.619466	0.570075	0.586314	0.684712
1990	0.571949	0.611200	0.566770	0.587077	0.663033
1991	0.569767	0.608554	0.562909	0.581972	0.657529
1992	0.564362	0.602142	0.556414	0.573249	0.643467
1993	0.558148	0.598553	0.553333	0.561157	0.636222
1994	0.554362	0.590885	0.539542	0.556084	0.620537
1995	0.548005	0.579735	0.528644	0.544682	0.595249
1996	0.543818	0.577706	0.526904	0.536908	0.590903
1997	0.542071	0.579608	0.533359	0.533875	0.598078
1998	0.541071	0.581988	0.545145	0.534346	0.605210
1999	0.539231	0.585252	0.549388	0.532539	0.614123

Table 2. Inequality indexes of income and CO_2

Year	CO_2 Theil	Theil between	Theil within	Within group 1	Within group 2	Within group 3	Within group 4	Theil between (%)	Theil Within (%)	Within group 1 (%)	Within group 2 (%)	Within group 3 (%)	Within group 4 (%)
1971	0.8385	0.5537	0.2848	0.0034	0.1575	0.0345	0.0893	66.04	33.96	0.41	18.79	4.12	10.65
1972	0.8418	0.5574	0.2843	0.0033	0.1588	0.0326	0.0896	66.22	33.78	0.39	18.87	3.87	10.64
1973	0.8392	0.5638	0.2754	0.0031	0.1592	0.0304	0.0826	67.18	32.82	0.37	18.98	3.63	9.84
1974	0.8239	0.5446	0.2793	0.0033	0.1681	0.0296	0.0783	66.10	33.90	0.40	20.40	3.59	9.51
1975	0.7951	0.5149	0.2802	0.0033	0.1707	0.0310	0.0752	64.76	35.24	0.42	21.47	3.90	9.46
1976	0.8059	0.5300	0.2759	0.0033	0.1662	0.0302	0.0762	65.77	34.23	0.41	20.62	3.75	9.45
1977	0.7912	0.5181	0.2731	0.0033	0.1610	0.0306	0.0783	65.48	34.52	0.41	20.35	3.86	9.89
1978	0.7785	0.5114	0.2671	0.0032	0.1576	0.0293	0.0771	65.69	34.31	0.41	20.24	3.76	9.91
1979	0.7725	0.5099	0.2626	0.0031	0.1588	0.0288	0.0718	66.01	33.99	0.40	20.56	3.73	9.30
1980	0.7608	0.4971	0.2637	0.0033	0.1635	0.0302	0.0667	65.34	34.66	0.43	21.50	3.97	8.76
1981	0.7527	0.4812	0.2715	0.0039	0.1697	0.0324	0.0656	63.93	36.07	0.51	22.54	4.30	8.72
1982	0.7341	0.4633	0.2708	0.0041	0.1718	0.0340	0.0609	63.11	36.89	0.56	23.40	4.63	8.30
1983	0.7283	0.4591	0.2693	0.0044	0.1693	0.0354	0.0601	63.03	36.97	0.61	23.24	4.86	8.26
1984	0.7254	0.4617	0.2637	0.0046	0.1623	0.0353	0.0615	63.65	36.35	0.63	22.38	4.87	8.47
1985	0.7159	0.4551	0.2608	0.0052	0.1594	0.0350	0.0612	63.57	36.43	0.72	22.27	4.89	8.54
1986	0.7018	0.4455	0.2563	0.0057	0.1581	0.0345	0.0580	63.48	36.52	0.82	22.53	4.92	8.26
1987	0.6988	0.4432	0.2556	0.0060	0.1559	0.0344	0.0593	63.42	36.58	0.86	22.31	4.92	8.49
1988	0.6940	0.4440	0.2500	0.0065	0.1520	0.0327	0.0588	63.97	36.03	0.93	21.90	4.72	8.47
1989	0.6847	0.4469	0.2378	0.0072	0.1451	0.0293	0.0562	65.27	34.73	1.05	21.20	4.27	8.20
1990	0.6630	0.4431	0.2199	0.0079	0.1360	0.0260	0.0500	66.83	33.17	1.18	20.52	3.92	7.54
1991	0.6575	0.4438	0.2137	0.0092	0.1320	0.0259	0.0466	67.50	32.50	1.39	20.08	3.94	7.09
1992	0.6435	0.4480	0.1955	0.0098	0.1119	0.0255	0.0482	69.62	30.38	1.53	17.39	3.97	7.48
1993	0.6362	0.4536	0.1826	0.0110	0.0934	0.0262	0.0520	71.30	28.70	1.73	14.67	4.12	8.18
1994	0.6205	0.4604	0.1602	0.0111	0.0720	0.0249	0.0522	74.19	25.81	1.78	11.60	4.01	8.42
1995	0.5952	0.4476	0.1477	0.0119	0.0617	0.0254	0.0486	75.19	24.81	2.00	10.37	4.27	8.17
1996	0.5909	0.4480	0.1429	0.0128	0.0550	0.0263	0.0488	75.81	24.19	2.17	9.31	4.44	8.27
1997	0.5981	0.4583	0.1398	0.0131	0.0495	0.0245	0.0527	76.62	23.38	2.19	8.27	4.10	8.81
1998	0.6052	0.4698	0.1354	0.0131	0.0492	0.0216	0.0515	77.63	22.37	2.17	8.13	3.57	8.50
1999	0.6141	0.4750	0.1392	0.0135	0.0521	0.0214	0.0523	77.34	22.66	2.20	8.48	3.48	8.51

Table 3. Contribution to inequality of between group and within group components

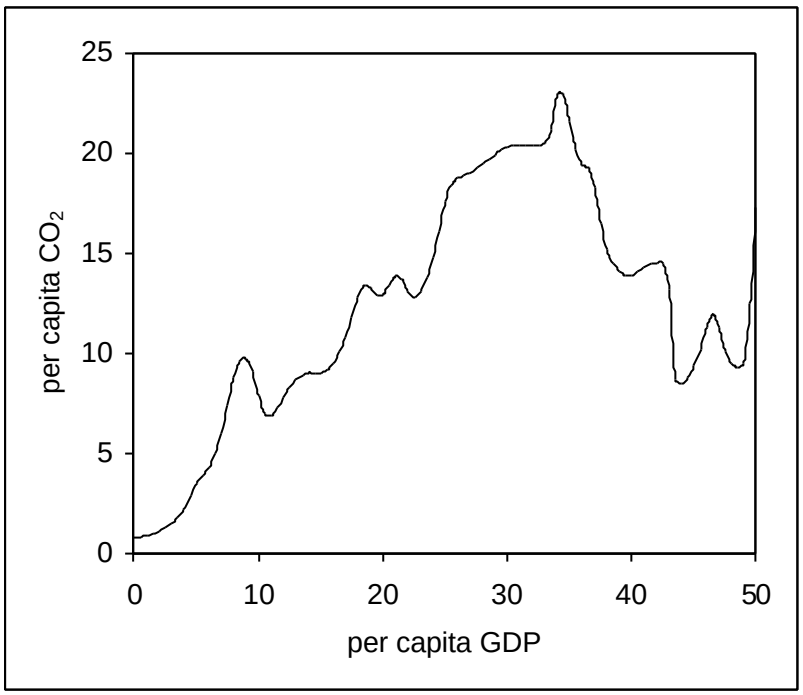

Figure 1. Non- parametric estimation between per capita CO_2 and per capita GDP for all the observations of the period

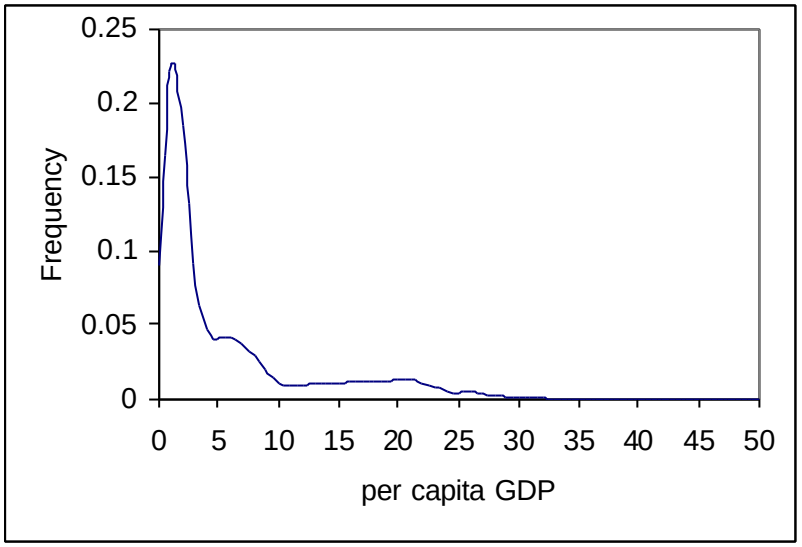

Figure 2. Population density function of per capita GDP for all the observations

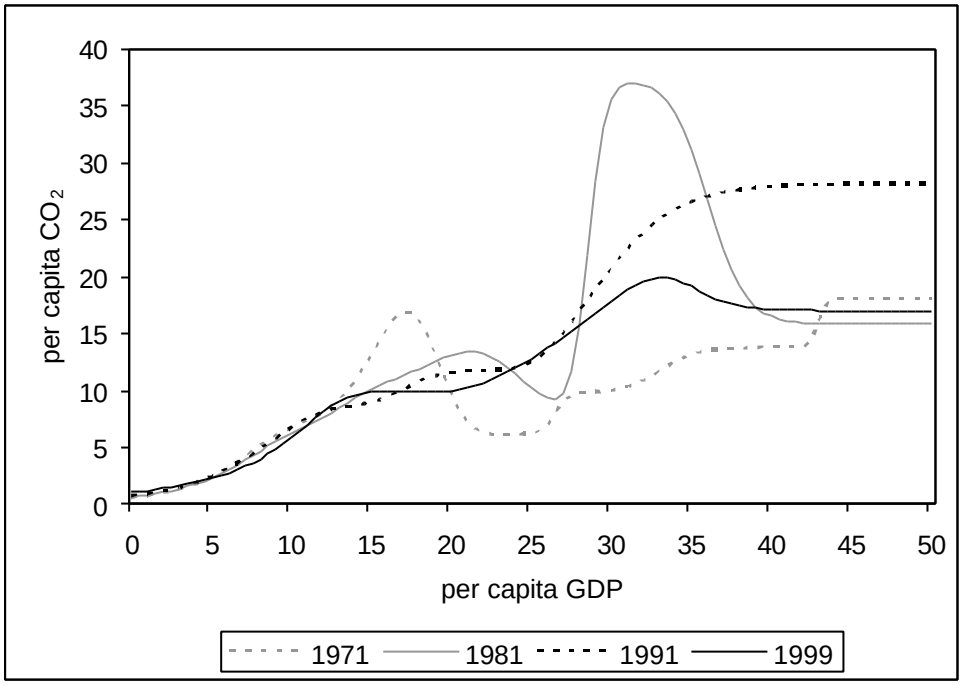

Figure 3. Non-parametric estimation of per capita CO_2 and per capita GDP for 1971, 1981, 1991, 1999

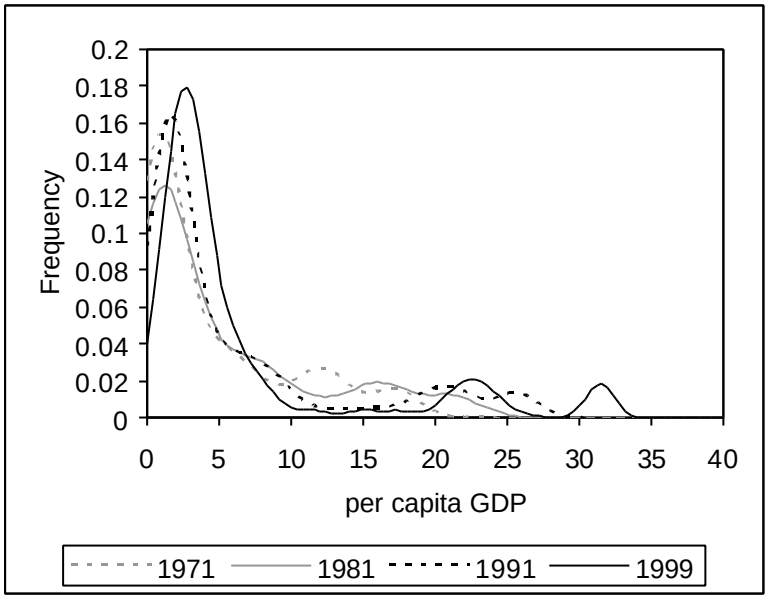

Figure 4. Population Density function of per capita GDP

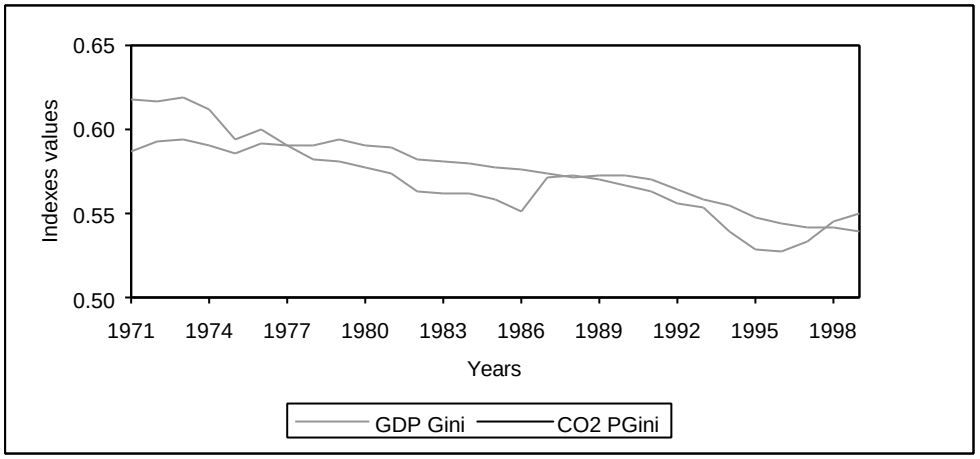

Figure 5. Evolution along time of the distributive relationship between CO_2 inequality and GDP

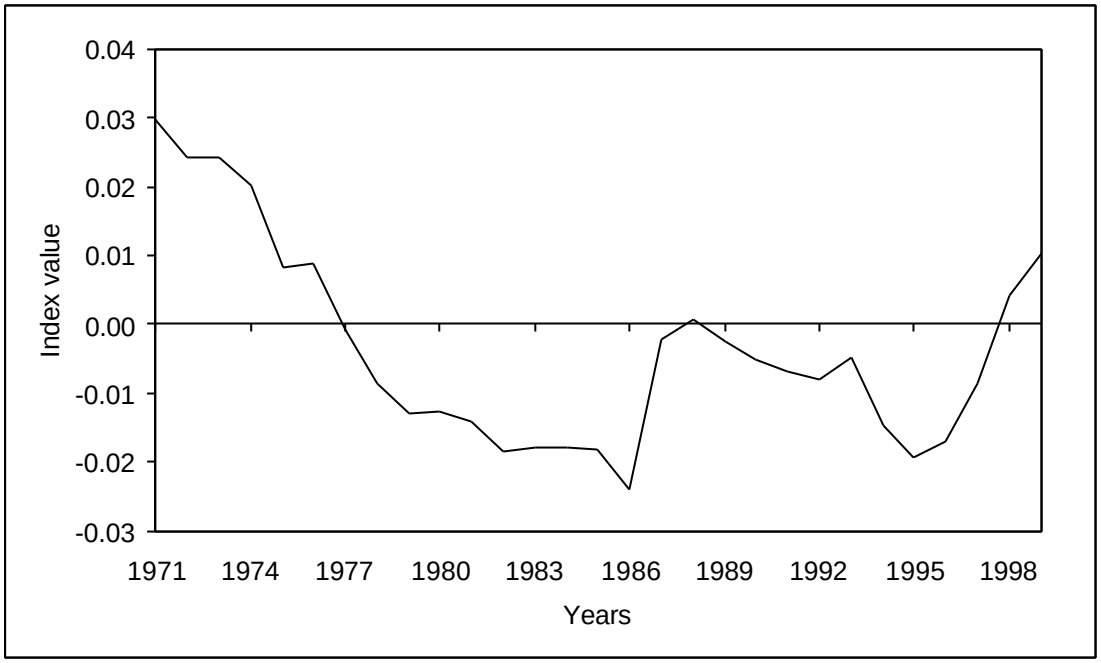

Figure 6. Kakwani index

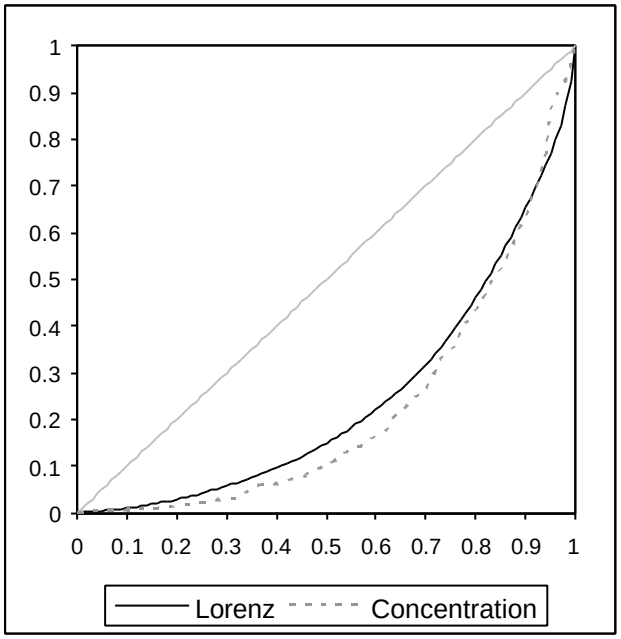

Figure 7. Lorenz curve of income and concentration curve of emissions for 1971

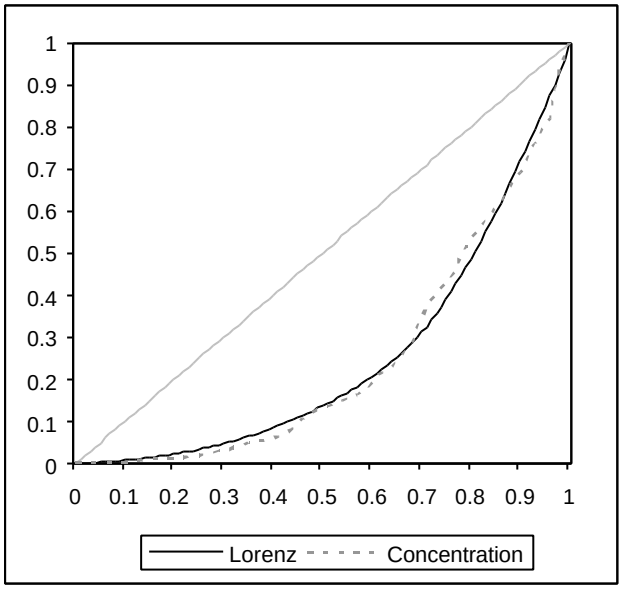

Figure 8. Lorenz curve of income and concentration curve of emissions for 1999

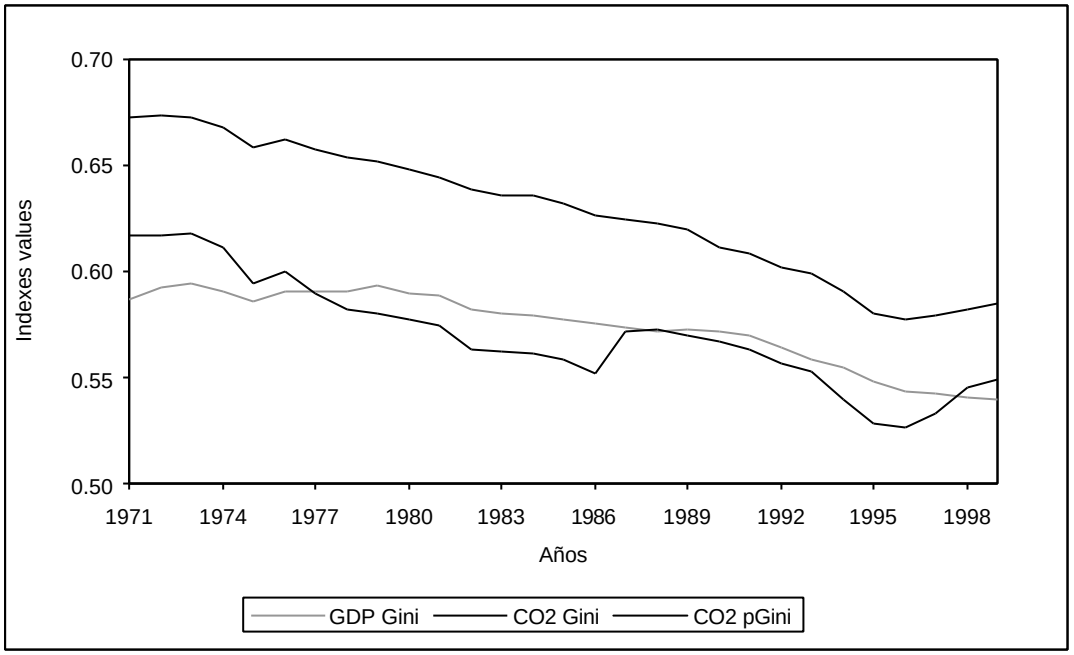

Figure 9. Gini indexes of CO_2 and GDP

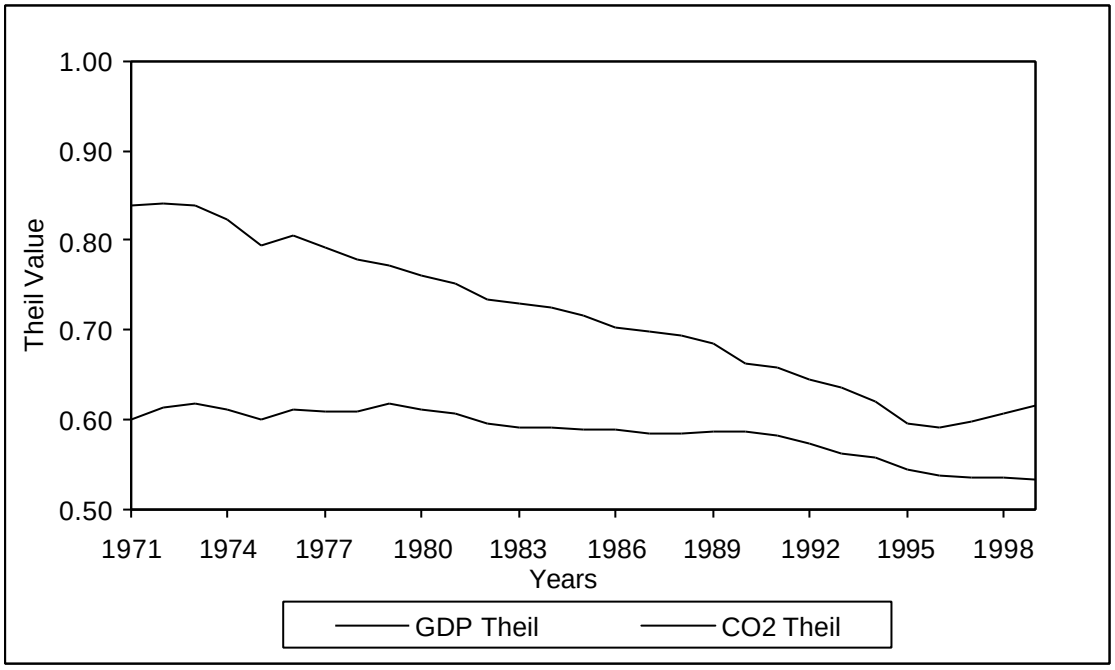

Figure 10. Theil indexes of CO_2 and GDP

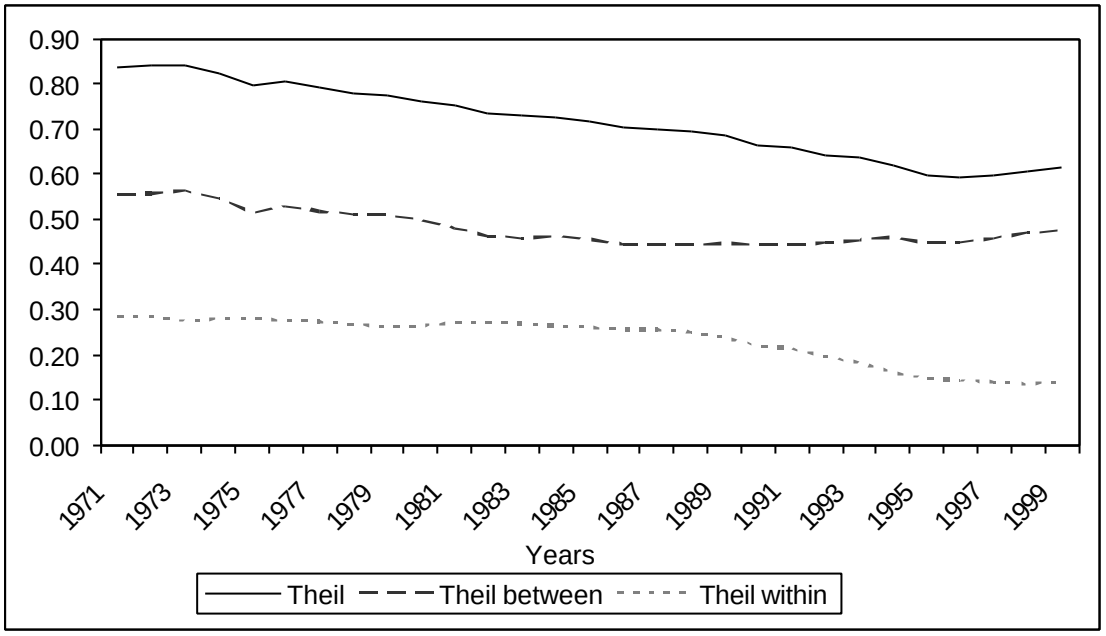

Figure 11. Decomposition of the Theil index of CO_2

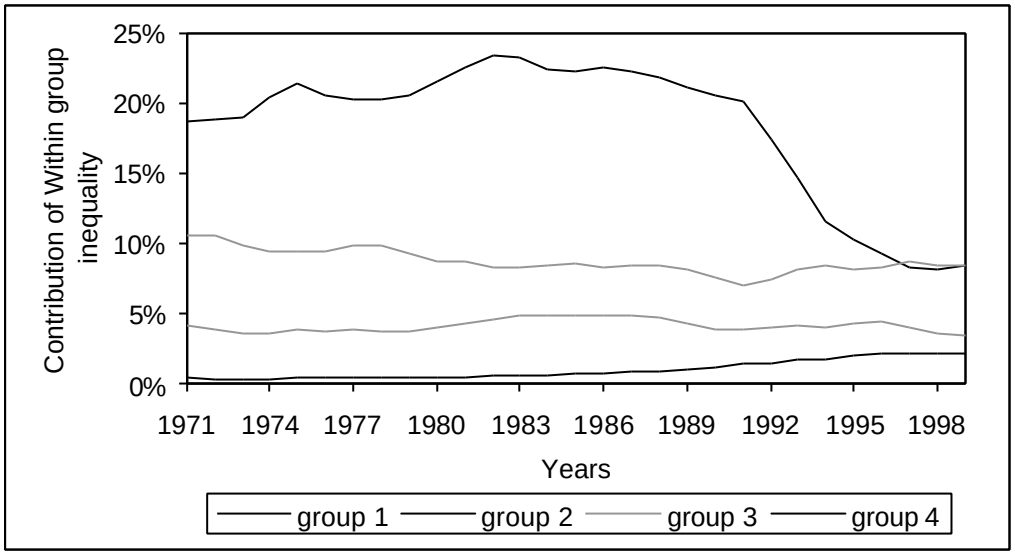

Figure 12. Contribution to the Theil index of CO_2 of within group inequality

Últims documents de treball publicats

NUM	TÍTOL	AUTOR	DATA
05.03	Inequality in CO2 emissions across countries and its relationship with income inequality: a distributive approach	Emilio Padilla / Alfredo Serrano	Gener 2005
05.02	Environmental management problems, future generations and social decisions	Joan Pasqual / Emilio Padilla	Gener 2005
05.01	International inequalities in per capita CO2 emissions: a decomposition methodology by Kaya factors	Juan Antonio Duro / Emilio Padilla	Gener 2005
04.12	Eficiencia y equidad en la ubicación de bienes colectivos locales indivisibles	Joan Pasqual	Novembre 2004
04.11	Regional Income Inequalities in Europe: An Updated Measurement and Some Decomposition Results	Juan Antonio Duro	Octubre 2004
04.10	Caracterización de la privación y de la pobreza en Catalunya	Sara Ayllon / Magda Mercader / Xavier Ramos	Octubre 2004
04.09	Social exclusion mobility in Spain, 1994-2000	Ambra Poggi	Setembre 2004
04.08	Sources of Competitiveness in Tourist Local Systems	Rafael Boix / Francesco Capone	Setembre 2004
04.07	"WHO PARTICIPATES IN R&D SUBSIDY PROGRAMS?. The case of Spanish Manufacturing Firms"	J. Vicente BLANES / Isabel BUSOM	Agost 2004
04.06	Una aproximación sectorial a la localización industrial en Cataluña	Anna Matas Prat José Luis Roig Sabaté	Juny 2004
04.05	Firm Strategies in R&D: Cooperation and Participation in R&D Programs	Isabel Busom, Andrea Fernández-Ribas	Abril 2004
04.04	Unemployment, growth and fiscal policy: new insights on the hysteresis hypothesis	Xavier Raurich, Hector Sala, Valeri Sorolla	Abril 2004
04.03	Polarització comarcal de rendes a Catalunya	Juan Antonio Duro	Març 2004
04.02	Análisis de agrupaciones provinciales a partir del enfoque de desigualdad y polarización: una nota	Juan Antonio Duro	Març 2004
04.01	Producción, empleo y eficiencia productiva de la empresa española	Oriol Roca Segalés Hector Sala Lorda.	Gener 2004