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Income inequality and carbon emissions

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Abstract

We document a U-shaped relationship between income inequality and carbon dioxide emissions per capita, using a newly available panel data set on income inequality (GINI) with observations for 138 countries over the period 1960–2008. Our findings suggest that, for high-income countries with high income inequality, pro-poor growth and reduced per capita emissions levels go hand in hand.

KEYWORDS: environmental quality, income inequality, panel data.
JEL CODES: I3, O1, Q3.

1. Introduction

Climate change and absolute income poverty are two major challenges facing mankind in the twenty-first century. As is well known (Bourguignon [2], Klasen [10]), distribution-neutral growth serves to lower absolute poverty, while growth that is associated with reduced income inequality, or 'pro-poor growth' has a larger poverty-reducing effect. At the same time, literature on the environmental Kuznets curve (EKC) and on climate change suggests that increases in economic activity are responsible for observed and projected climate change; the effect of inequality change on emissions is, however, less clear. Analyzing the role of inequality for emissions is, however, critical to understanding possible trade-offs between pro-poor growth and climate change.

In this paper, we analyze the relationship between income inequality and carbon dioxide emissions per capita. To investigate this issue, we use unbalanced panel data for 138 countries for the period 1960-2008 in combination with a fixed effects (FE) panel data model for per capita carbon emissions that introduces nonlinearities in per capita income and income inequality. We contribute to the existing literature on the relationship between income inequality and carbon emissions by using a much more comprehensive data set on income inequality that also deals with consistency issues in these data; in addition, we consider non-linear effects of inequality on emissions which was not done before and leads to substantially different conclusions. Our main finding is that the relationship between income

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inequality and carbon dioxide emissions is U-shaped while there is also a (well-known) non-linear income-emissions relationship (IER). Furthermore, we find that this finding is robust against a wide range of specification changes but differs across countries: in high-income countries the turning point is at much lower levels of inequality so that the possibility of emission-reducing pro-poor growth is more feasible there, while most poorer countries indeed face a trade-off between lowering inequality and increasing per-capita emissions.

Income inequality can influence carbon emissions per capita through various channels whose relative strength might depend on the stages of economic development. An overview of the theoretical arguments for the role of income inequality for emissions can be found in Borghesi [1]. In the next paragraphs we briefly describe two of them, namely aggregation bias and political economy arguments.

Ravallion et al. [11] point out that in a simple model where the marginal propensity to emit (MPE) falls with income, income inequality enters the income-emissions relationship. There is some evidence that the MPE varies with the level of income, see e.g. Holtz-Eakin and Selden [9] and Heil and Selden [7]. If the poor have a higher MPE, increasing inequality will improve aggregate environmental quality conditional on average income. A related reasoning can be found in Heerink et al. [6]: if an inverted-U shaped relationship is assumed between household income and household carbon emissions, aggregating over households will also result in a negative relationship between income inequality and carbon emissions per capita.

This effect might be strengthened if the MPE rises with income for the poorer sections of the population in poor countries, e.g. because the poor in a poor country have no access to modern energy. Increasing inequality will then reduce marginal emissions of richer population segments, *and* reduce emissions of poorer segments as they are pushed out of the carbon economy.

Conversely, the MPE might rise with income due to the high energy-intensity of luxury good consumption. As different effects may dominate at different levels of income, the effect of inequality on emission could be U-shaped.

Based on political economy considerations, Boyce [3] and Torras and Boyce [12] assume that, in more unequal societies, those who benefit from pollution are more powerful than those who bear the cost. Therefore, the cost-benefit predicts an inefficiently high level of pollution. This implies a positive correlation between income inequality and pollution.

These two arguments point towards complex and possibly non-linear effects of income inequality on emissions which may depend additionally on income levels.

Previous empirical work on the relationship between per capita CO_2 emissions and income inequality is limited. Ravallion et al. [11] use a pooled OLS model and find that income inequality is negatively associated with carbon emissions. Borghesi [1] rejects the pooled OLS specification in favour of a FE panel data estimator and finds that there is no statistically significant relationship between income inequality and carbon emissions per capita. Finally, Heerink et al. [6] use a cross-section and find a negative correlation. None of these authors tested for nonlinearities in inequality.

These studies rely on the GINI income inequality measure from the data described in Deininger and Squire [4] and estimate the model using a limited number of years. An important contribution of this paper is the use of a comprehensive data set of comparable GINI coefficients based on Gruen and Klasen [5]. This allows us to use a much larger set of countries (138 instead of 42/37/64) and observations for the period 1960–2008 (compare 1975–1992/1988–1995/1985).

2. Data and model

We use an unbalanced data set covering 138 countries from 1960 until 2008 with 1332 observations. The variables of interest are GDP per capita, CO_2 emissions per capita and income inequality (GINI).

Starting point for the income inequality data is the WIDER World Income Inequality Database, to which the treatment proposed in Gruen and Klasen [5] is applied. We also apply a regression-based approach that addresses the heterogeneity of GINI coefficients. This deals with, among others, heterogeneity in consistency of the income concept and the unit considered, caused by the fact that the data can be based on either income or expenditure data, and can originate from either individuals or households, or may use some equivalence scales.

The data on national CO_2 emissions is taken from the Oak Ridge National Laboratory and covers emissions from fossil fuels, natural gas consumption as well as cement manufacturing. The use of this data set is well established in the literature but faces two major shortcomings. First, it is estimated data which is based on the consumption of fossil fuels multiplied with the average carbon content of the respective fuel type. And second, it does not account for emissions from agriculture, life stock, deforestation or land use change. Therefore, it might underestimate the CO_2 emissions for countries with a large agricultural sector or where deforestation is a major source of emissions. Real GDP per capita is taken from the Penn World Tables 7.0 and is purchasing power adjusted to allow for international comparison, see Heston et al. [8].

Our model extends an EKC to allow for an income inequality effect. To approximate a possibly nonlinear function in GDP per capita and GINI, we propose the following second-order approximation:

$$\log(\mathrm{CO}_2)_{i,t} = \alpha_i + \lambda_t + \beta_1 \log(\mathrm{GDP})_{i,t} + \beta_2 log^2(\mathrm{GDP})_{i,t} + \beta_3 \log(\mathrm{GINI})_{i,t} + \\ + \beta_4 \log^2(\mathrm{GINI})_{i,t} + \beta_5 \log(\mathrm{GDP})_{i,t} \cdot \log(\mathrm{GINI})_{i,t} + \varepsilon_{i,t}, \quad (1)$$

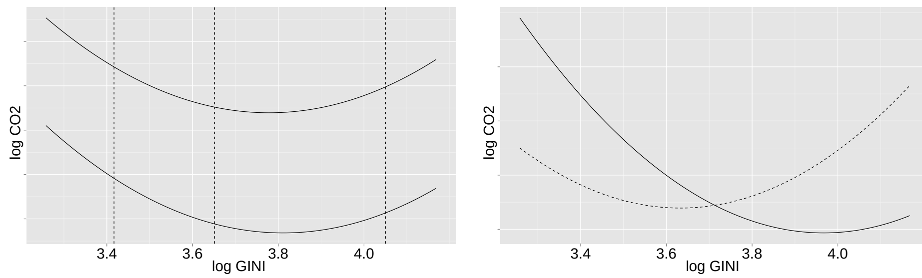

Figure 1: Estimated relationships between income inequality and per capita carbon emissions. Left panel: Top line is for the 55th percentile of GDP per capita in 2000; bottom line is 45th percentile. Dotted vertical lines indicate empirical percentiles 10, 50 and 90 of GINI in 2000. Right panel: Curves are normalized to have mean zero. Solid line is for the 1st percentile for GDP per capita in 2000, the dashed line is for the 99th percentile.

where i denotes an arbitrary country in our sample, t is an arbitrary time period, and α_i and λ_t denote individual and time effects. The coefficients of this model can be estimated using a FE panel data estimator. The interaction effect enters our model naturally because we use a second-order approximation. It allows both the level and the shape of the relationship between CO_2 emissions per capita and income inequality to depend on the value of GDP per capita.

3. Results

Our most important finding is that the relationship between carbon dioxide emissions per capita and income inequality is U-shaped: for countries characterized by high income inequality, reductions in income inequality are associated with lower per capita emissions. For less unequal societies, reductions in income inequality are associated with increases in carbon emissions per capita. The inequality effects are highly significant and thus clearly provide a better fit of the data than a linear effect used in previous research. The level at which reductions in income inequality stop being beneficial will depend on the level of GDP per capita.

Figure 1 plots the estimated emissions-inequality relationships. In the left panel, the dashed lines denote 10th, 50th, and 90th percentile of the empirical GINI distribution in 2000, so that we can conclude that the turning point is in-sample. The two curves differ in their level of GDP per capita: the top line is for the 55th percentile of GDP in 2000, the bottom line is for the 45th percentile. This shows that higher values of GDP per capita are associated with higher levels of CO_2 emissions per capita. In the right panel, we plot two normalized emission-inequality relationships for two values of GDP per capita that are further away from each other. The economic significance of the interaction term becomes obvious: for poor countries, the turning point of the relationship shifts to higher values of income inequality (from a GINI of about 0.37 to a GINI of about 0.55 as we move from the 1st to the 99th percentile of per-capita incomes).

The coefficient estimates for our preferred specification can be found in Table 1, column 1. In the adjacent columns, we present a small part of our extensive sensitivity analysis. A Hausman test rejects the specification in column *RE* in favour of our benchmark specification.Column *Linear* shows that one would conclude that the relationship between income inequality and per capita carbon emissions is negative if a linear specification is used. (Ravallion et al. [11], Heerink et al. [6]). The last two columns of Table 1 show that our results are robust against the level of aggregation of the data: using data aggregated to 3- and 10-year averages yield results close to the benchmark output.

This shows that the relationship between inequality and emissions is more complex than the previous literature had surmised. In particular, our findings are consistent with the aggregation bias argument and a more complex relationship between income and the MPE. For example, if there is a section of low incomes where the MPE is first 0 as people are outside of the carbon economy, then rises, then falls, and rises again at very high levels of incomes, this could deliver the results we find here, including the different turning-points for richer and poorer countries. Suggestive descriptive evidence supports this claim. When we divide up our sample in the last year into poorer and richer countries, we find that the unconditional correlation between income inequality and goods proxying the access and intensity of use of the carbon economy (cars or vehicles/1000 population and televisions) is strongly negative for poorer countries, and strongly positive for richer countries. Thus in poorer countries higher inequality reduces access and use of these goods, while in richer countries it increases it, confirming the supposition that the poor in poor countries are largely outside of the carbon economy while in rich countries, higher incomes might be associated with a rising MPE. The findings are also consistent with a combination of the aggregation and political economy arguments, with the latter dominating at higher levels of inequality.

The findings suggest an opportunity for pro-poor, low-carbon development for unequal rich countries. Those countries can promote pro-poor growth and experience declining emissions as a result. For poorer countries, only the most unequal ones could engage in pro-poor growth and reduce per capita emissions. More equal poor countries face a trade-off.

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	Benchmark	RE	Linear	3-year	10-year
log(GDP)	2.09	0.73	2.57	2.22	1.67
	(0.33)	(0.66)	(0.28)	(0.46)	(0.54)
$\log^2$(GDP)	-0.11	-0.02	-0.11	-0.11	-0.11
	(0.02)	(0.04)	(0.02)	(0.02)	(0.03)
log(GINI)	-7.22	-6.38	-0.29	-6.79	-8.84
	(1.31)	(1.98)	(0.08)	(1.60)	(3.09)
$\log^2$(GINI)	0.79	0.69		0.76	0.86
	(0.13)	(0.15)		(0.18)	(0.40)
log(GDP) · log(GINI)	0.14	0.13		0.12	0.27
	(0.08)	(0.13)		(0.07)	(0.07)
Observations	1332	1332	1332	795	410
R^2	0.60	0.60	0.61	0.52	0.53
Countries	138	138	138	138	138

Table 1: Output for benchmark model and sensitivity analysis. Individual and time effects are suppressed. Robust standard errors are in parentheses.

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