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Geographical spread of global emissions: Within-country inequalities are large and increasing

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HIGHLIGHTS

- We estimate global spatial CO_2 and CH_4 inequality using grid data for 1970–2008.
- Overall spatial emission inequality is constant for CO_2 and increasing for CH_4.
- Within-country inequality is rising and constitutes the main bulk of overall inequality.
- An important part of within country inequality is due to differences among sectors.
- The gap between emitters and victims is rising within countries.

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ABSTRACT

In spite of the extensive literature on greenhouse gas emission inequalities at the world-wide level, most of the evidence so far has been based on country-level data. However, the within-country dimension matters for both the implementation and the policy formation of climate policies. As a preliminary step towards a better understanding of within-country inequalities, this paper measures their extent for the two major greenhouse gases, CO_2 and CH_4, over the 1970–2008 period. Using Theil-index decompositions, we show that within-country inequalities account for the bulk of global inequality, and tend to increase over the sample period, in contrast with diminishing between-country inequalities. Including differences across sectors reveals that between-sector inequalities matter more than between-country inequalities, and between-sector inequalities become the dominant source of global inequality at the end of the sample period in the CO_2 case. Finally, estimated social tensions arising from the disconnection between emissions and future damages turn out to be increasing as soon as within-country disparities are taken into account. These orders of magnitude should be kept in mind while discussing the efficiency and fairness of alternative paths in combating global warming.

1. Introduction

In face of the mounting risk of man-induced catastrophic changes in global climate and ecosystems, a large literature has emerged regarding the spatial distribution of environmental indicators on the Earth surface. This has been particularly true in the case of greenhouse gas (GHG) emissions, with a flurry of studies devoted to the issue of their convergence in per capita terms across countries (e.g. Pettersson et al., 2013 for a survey). Although the spatial inequality of GHG emissions between countries is well documented, it is fair to say that very little is known regarding the behavior of this indicator within countries. This is relatively surprising, as within-country inequalities are generally recognized as an important policy determinant in regional economics (e.g. Rey and Janikas, 2005, Chancel and Piketty, 2015).

Within-country spatial emission inequalities may matter regarding climate policy for at least four reasons. First, the more widespread pollution sources are, the larger are costs of implementing and monitoring environmental policies (although this

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efficiency argument must be refined to include marginal abatement costs, which do differ strongly across locations). Second, the literature on the political economy of environmental policy emphasizes the important role of lobbying groups in the formation of environmental policies (see for instance Oates and Portney, 2003 or Aidt, 1998). Hence spatial within country inequalities are important because they might shape national environmental policies via the interaction of different sub-national interest groups. As Clarke-Sather et al. (2011) put it: "internal dynamics of carbon inequality have the potential to shape future energy policies". Third, we observe today an emerging trend towards sub-national and/or sectoral policies regarding GHG emissions. Barrett (2008) for instance proposed to break the problem up and to rely on separate agreements addressing different gases and sectors. Another example is given by the World Bank which recently launched the idea of a global network of carbon markets (see World Bank, 2013). Fourth, the political tensions that exist at the international level between the countries most exposed to the negative consequences of climate change and the major emitters of GHG also exist at the subnational level, between emission-producing areas and damage-exposed areas, generating social tensions that affect the decision process. For all these reasons, we believe that investigating sub-national inequalities is strongly relevant for the design of energy and climate policies.

Relying on a database which reports GHG emissions at a very disaggregated level over the 1970–2008 period, this paper proposes an in-depth analysis of spatial inequalities in global warming related emissions for the two major GHGs, carbon dioxide (CO_2) and methane (CH_4). We use a spatial Theil index, which measures how unevenly polluting emissions per hectare are spread across the Earth's surface. This index allows the analysis of structural determinants of inequality, as it can be decomposed into the contribution of geographical groups on different hierarchical levels (e.g. country groups, countries) and emission sources (e.g. sectors). It thereby provides answers to the following questions: By how much do we underestimate global emission inequality when choosing countries as basic units of analysis? How do the contributions of between and within country inequality evolve over time? Which specific sector/country combinations contribute more than proportionally to global emission inequality? And finally, as an illustration of the importance of these measures in the policy debate, what is the degree of overlapping between the geographical distribution of current emissions and the geographical distribution of future damages?

The next section locates the paper within the literature, by proposing a selected review of the studies on emission per capita inequalities and on the relevance of sub-national approaches to policy determinants. Data and methods are described in Section 3, followed by the presentation of results in Section 4. Policy implications and further research avenues are discussed in the conclusion.

2. Selected literature review

Since this paper is the first attempt to characterize geographical within-country emission inequalities, we cannot directly rely on a specific literature. However we build our paper on two related strands of the literature outlined below. We provide a brief reminder of the large literature on the distribution and the convergence of per capita emissions over the past two decades, then select a few recent studies which illustrate the importance of considering inequalities at the sub-national level. Finally, we present the contribution of our paper.

Taking up the distinction by Duro (2015), the analysis of emission distributions can be divided in two major approaches: (a) convergence analysis (σ- and β-convergence); (b) inequality analysis of emission distributions with a focus on the properties of the indicators used and the possibility of their decomposition. Although our paper belongs to the second approach, we start here with a review of the convergence literature, which has generated a large body of evidence over the last two decades. The abundance of the emission convergence literature has two main explanations. The first explanation is policy relevance. In the climate negotiation framework it is largely acknowledged that differences in responsibilities should be taken into account in international negotiations such that the final outcome can be considered as fair.[1] Among the basic principles that have been proposed to allocate emissions among nations, the per capita principle is the most frequent one (e.g. Mattoo and Subramanian, 2010). In addition, convergence assumptions are fundamental elements of the long run emission projection models on which IPCC reports are based. A thorough understanding of whether emissions per capita are converging, and what the influential factors are, is thus a cornerpiece of international climate negotiations.

The second explanation is methodological convenience and timeliness. Starting at the end of the nineties, the emission per capita debate has taken full advantage of the existing empirical literature on income per capita levels it is derived from (a similar filiation exists between the environmental Kuznets curve and the original one). The theoretical underpinning is similar (Brock and Taylor (2010) explain emission convergence on the basis of a simple extension of the Solow (1956) income growth model) and the empirical analysis could be performed relying on the same analytical tools (the survey by Pettersson et al. (2013) identifies three categories; traditional σ- or β-convergence, dynamic distributional analysis and stochastic convergence). As data availability improved quickly, studies led to a situation which is reminiscent of the income convergence literature, namely quite a large variety of results depending on the methodology used.[2] In the end, most results point towards convergence, but of the conditional type, with factors such as technological change and innovation, fossil fuel substitution and industry outsourcing also playing a role (e.g. Presno et al., 2015).

Some comments are in order. They will drive us closer to the second approach, which relies on inequality measurements. First, the link between income per capita and emissions per capita is far from direct. In particular, as clarified by the famous IPAT identity, it is mitigated by energy intensity and by carbon intensity. This has led to a flurry of recent studies analyzing the convergence of energy intensities (e.g. Duro, 2010 or Mulder and de Groot, 2012), or the causes of regional inequalities in emissions (e.g. Padilla and Duro, 2013 in the EU case). Second, as argued by Villaverde and Maza (2011) on the basis of data collected by Dreher et al. (2008), the convergence trend is part of a larger globalization process, and affects not only the economic, but also the social and the political spheres, with many possible interactions. For example, Padilla and Serrano (2006) find that inequality in CO_2 emissions across countries is mostly explained by income inequality between country groups, not within country groups. Income levels and

[1] The theoretical and empirical literature on climate change policy negotiations emphasizes clearly the importance of fairness as a criteria for successful international and national negotiations (see for instance Cantore, 2011; Rübbelke, 2011; Kverndokk and Rose, 2008; Lange et al., 2007; Paavola and Adger, 2006; Barrett and Stavins, 2003; Ringius et al., 2002 and Rose et al., 1998). Using the words of Barrett and Stavins (2003, p. 358): "Concerns for fairness are not merely abstract notions. They are important for negotiations. People often refuse offers they perceive to be unfair, even when doing so comes at significant personal cost. In principle, it should be possible to negotiate a treaty that is both efficient and fair."

[2] See for instance Grunewald et al. (2014), Duro et al. (2013), Duro (2012), Ordas and Grether (2011), Groot (2010), Cantore and Padilla (2010), Coondoo and Dinda (2008), Duro and Padilla (2006), Heil and Wodon (2000, 1997).