Ecological Indicators 66 (2016) 173–179

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Intercountry inequality on greenhouse gas emissions and world levels: An integrated analysis through general distributive sustainability indexes

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ARTICLE INFO

Article history:
Received 14 August 2015
Received in revised form 13 January 2016
Accepted 18 January 2016

Keywords:
Sustainability indexes
Greenhouse gases
Environmental equity

ABSTRACT

Up until now, analyses of the inter-country distribution of pollutant emissions have not paid sufficient attention to the implications that, in terms of global sustainability, the combined evolution of the global world average entails. In this context, this paper proposes the use of general distributive sustainability indexes in order to make a comprehensive examination of the international equity factor and also the mean (world) factor in this field. The proposed methodology, which is adapted from the welfare and inequality economics literature, is implemented empirically in order to explore the evolution of the greenhouse gases and its main components: CO_2, CH_4 and N_2O during the period 1990–2012. The main results found are as follows: firstly, typically, the general distributive sustainability associated with the overall greenhouse gases in per capita terms increased over the global period but, contrarily, it seems to decrease since 2000; secondly, typically this last reduction is basically explained by the increase in world mean average, given the clear reduction on cross-country inequalities; thirdly, the analysis of different gases also points out some differences in temporal variations and depending on the index used. These results would seem to be relevant in policy and academic terms.

1. Introduction

The environmental sustainability of the planet is one of the most important global challenges facing society. As a consequence, for example, successive summits on climate change have become the main forum for warning about this threat and attempting to implement mitigation strategies. It is a situation brought about, essentially, by a model of world economic growth that consumes resources intensively and which tends to be insensitive to negative global externalities and long term impacts. In reality, the concept of global sustainability embodied, for example, in the necessary reduction in the level of pollutants released into the atmosphere, can be interpreted as an intergenerational distributional matter, inasmuch as it affects the wellbeing of future generations (Neumayer, 2010). Yet, at the same time, the excessive consumption of resources, given their finite nature, also makes it necessary to consider the problem of sustainability in terms of intra-generational equity (Anand and Sen, 2000). As Daly said (1992), an equitable distribution is a necessary and ethical condition for sustainability. Thus, environmental sustainability should incorporate not only global elements in terms of the planet, but also, to a great extent, equitable distributions (UNDP, 2011).

Once at this point, the question becomes one of deciding which type of distribution is most relevant. Whilst the temptation exists to pose the question in personal terms, it would seem reasonable to analyse environmental equity, and through it the different level of responsibility and how it is shared, based on countries. Countries are the basic units of world governance; they possess the main instruments of policy and, consequently, they are the ones that typically negotiate definitive environmental objectives on a global level.[1] In fact, as an additional concrete example in support of the relevance of a distributional analysis by country, consider the fact that a more inequitable situation between countries in environmental terms would tend to distance their respective strategic

[1] In any case, evidence would seem to suggest that the bulk of personal inequalities in average pollution levels on a global scale could simply be explained by the differences between countries, at least during the period analysed in this paper. Thus countries would form a good synthesis of the distributive situation at a global level (Chancel and Piketti, 2015).

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http://dx.doi.org/10.1016/j.ecolind.2016.01.026
1470-160X/

positions in global negotiations, which would reduce the possibility of reaching agreements, and thus threaten sustainability itself (Duro and Padilla, 2006). Specifically, from the Rio summit up to the most recent ones, there seems to be little argument that inequalities between countries, frequently but not exclusively framed in the context of developed countries and emerging or developing countries, have conditioned the scale of any conflicts as well as the possibility and type of agreements reached, typically for the worse. This being the case it seems reasonable, therefore, in terms of the analysis of global environmental sustainability, to examine both the environmental inequalities between countries at the same time as the evolution of world averages.

Specifically, the concern about the analysis of cross-country environmental inequalities has caused a voluminous empirical literature to date. Some examples of these, though by no means an exhaustive list, are Alcántara and Duro (2004), Hedenus and Azar (2005), Duro and Padilla (2006), White (2007), Ezcurra (2007), Cantore and Padilla (2010), Jobert et al. (2010), Steinberger et al. (2010) or Duro (2012). Essentially, these approaches entail establishing a correlation between the evolution of intercountry inequality, typically obtained from different synthetic indices consistent with the approach of Lorenz (Lorenz, 1902), and the degree of the global environmental problem (or a part of them). In this way, the higher the inequality, or the greater it grows, the worse the global scenario in terms of equity and, also, the environmental distributive situation. However, as also we said, comparisons of these inequality indices as elements for establishing conclusions in a global context do not take into account what happens to world levels. In particular, for the total GHGs, whose global levels progressed by 40% in the 1990–2012 period (in per capita terms a nearly 5%), inequalities among countries decreases and, therefore, a contradictory evolution in terms of general distributive sustainability (at a world level) is observed.

In these circumstances, it would be useful to have a conceptual framework that would allow both elements (inequalities and mean) to be brought together in one measurement and be able to make a global evaluation of the world distributive sustainability position. In this respect, an interesting conceptual approach comes from the welfare and inequality economics literature (Sen, 1976; Kakwani, 1986; Atkinson, 1970). In particular, Sen (1976) and Kakwani (1986) suggested the validity of using the called "social welfare indices" which, apart from the mean, also depend on the Gini inequality coefficient as a measurement of equity preference (i.e. inequality). Thus, these indices enable the comparison of different social states, as it is also our goal in environmental terms. By the same token, one should point out the appeal associated with indices deriving from Atkinson's approach (Atkinson, 1970) which, in particular, incorporates the added value of being able to modulate, in each global measurement, the size of the equity preference and hence the sensitivity of society to the inequality. Therefore, it would seem interesting to extend this approach, initially applied to the personal income analysis, to the analysis of our environmental indicators distribution.

This paper, thus, aims to carry out two tasks. The first of these, which is methodological, is to propose general distributive sustainability indexes in order to explore the international environmental distributions (basically, greenhouse gases) using the previous standard welfare and inequality economics literature (indices) as a theoretical base. Secondly, it intends to make an empirical implementation of these measures proposed to analyse the international distribution of greenhouse gases at a world level and their three main components: CO_2, CH_4 and N_2O, for the period 1990–2012.

The paper is structured as follows: Section 2 reviews the main methodological aspects associated with the proposal to apply the called social welfare functions and indexes to the analysis of general distributive sustainability. Section 3 makes an international application for various global pollutants associated with the greenhouse gas effect and Section 4 includes the main implications and conclusions derived from the paper.

2. Materials and methods

The economics of welfare and inequality enjoys a long tradition of employing the concept of social welfare and its associated functions to put different social states into order (Sen, 1976; Blackorby and Donaldson, 1978; Kakwani, 1986, among many others). In this respect, the theory typically uses two basic descriptor parameters to enable these social states to be ordered. Firstly, the global average and secondly its distribution. As these are typically applied to the analysis of personal income, it would seem reasonable to extend this theoretical framework to a specific analysis of environmental indicators at a country level given that, as previously mentioned, global sustainability should mean not only being concerned about the worldwide consumption of resources (from now on specifically pollutants) but also about the way it is shared amongst countries. The extension would seem novel because until now studies of the analysis of international pollutant distribution, for instance, have not paid enough attention in their comparative analyses to the effect, in global sustainability terms, that variations in the world mean figures may have.

In particular, and in terms of our analysis, one might find oneself at an empirical level with three possible hypothetical scenarios in terms of general distributive position and the two basic factors concerned. Firstly, it is possible to find an international (intercountry) distribution of pollutant emissions (pollutants divided by population[2]) indubitably less in egalitarian (in the sense of Lorenz, without intersections) that another one, and a global mean figure of pollutants lower than the latter one; secondly, it might be the case that also inequality can be lower with no ambiguity but with the former reflecting higher world pollutants levels; and thirdly, it may be the case that the Lorenz curves intersect and hence the strict Lorenz domination criterion cannot be applied.[3]

If the situation is similar to the first one, and now we will turn to the welfare and inequality economics literature, Atkinson (1970) demonstrated that the first distribution dominates the second one. In this case, therefore, the ranking of distributions based on inequality criterion (through the Gini coefficient, for example) would match the order in terms of general distributive sustainability. The problem arises with the second and third of these scenarios. Shorrocks (1983), in a well-known paper, introduced the general dominance criterion as a useful element in these cases (especially in the second scenario). Specifically, this solution would consist

[2] The use of emissions divided by population per country is very common in the specific literature that analyses the positions and environmental responsibility of the different countries, in terms of homogeneous comparisons (see Hedenus and Azar, 2005; Duro and Padilla, 2006; White, 2007; Cantore and Padilla, 2010; Jobert et al., 2010; Steinberger et al., 2010; and Duro, 2012, among many others).

[3] The Lorenz curve is the typical representation of the level of inequality of a distribution, indicating it in a visual way with a direct translation in terms of the Gini coefficient. If the analysis is made, for example, in terms of CO_2 per capita and country, it would involve putting the observations into ascending order with each point on the curve representing the accumulated percentage of relative population associated with the accumulated percentage of global emissions. The curve would always have a positive and curvilinear slope, moving within a support of between 0 and 1 (see the analysis in Steinberger et al., 2010, for example). When a curve approaches the line of equality it indicates the least inequality. If any two curves are compared and one is clearly nearer to the line of 45° it is said that Lorenz dominates the other and any inequality method would reflect that fact. The problem is when there are intersections, which of necessity requires the calculation of synthetic indices. See Duro (2012).