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International mobility in carbon dioxide emissions

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HIGHLIGHTS

- The evolution of international mobility in per capita CO_2 emissions for the period 1971–2007 is analysed.
- Several different synthetic mobility measures are used for capturing the various perceptions of mobility.
- The mobility is high and, in a significant way, without impact on distribution.
- There does not seem to be a clear, convincing relationship between mobility and the evolution of inequality.
- The results obtained have some implications in terms of analysis and environmental policy.

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ABSTRACT

In this paper, we analyse the evolution of international mobility in per capita CO_2 emissions for the period 1971–2007. This concept reveals the distribution's degree of entrenchment which is fundamentally different from other distribution concepts. In particular, we use several different synthetic mobility measures in order to capture the various perceptions of mobility proposed in the literature. This approach can be seen as complementary to the dynamics of distribution approach. The empirical analysis yields the following main results. First, the evolution observed varies according to the mobility index used. Second, when broader mobility indices are used, the most recent years analysed (i.e. 2000–2007) and the 1970s appear to be the most dynamic periods. Third, their decomposition reveals the major role played by the non-high income countries group. Fourth, the calculation of fictitious indices associated with the three major decomposition components of general mobility indicates that exchange (i.e. changes in position) and dispersion (i.e. distribution effects) have typically been the most important mobility factors. Finally, there does not seem to be a clear, convincing relationship between mobility and the evolution of inequality, which to a certain extent underscores the need to carry out a differential analysis for mobility. The results obtained have some implications in terms of analysis and environmental policy.

1. Introduction

Analyses on climate change mitigation, and so the reduction in CO_2 generation, involve considering the contribution and role of countries as uneven, taking into account their size. The distinctive role of each country, its individual responsibility and temporal changes should be taken into account by analysts, not only in terms of knowledge but also as a point of reference for sharing the load equitably. Authors such as Daly (1992), Daly and Farley (2004), Aubauer (2006) and Steinberger et al. (2010) have stressed, for example, the need to consider matters of environmental equity as an ethical condition for global development. Evidence of this concern has been reflected in the massive growth of published academic works focussed on the study of the international distribution of CO_2 emissions using varying approaches. Thus, there are papers examining this issue, for example, by borrowing the tools used in the convergence-economic growth literature; representative papers include Strazicich and List (2003), Aldi (2006), Romero-Ávila (2008), Jobert et al. (2010)) and Barassi et al. (2011). On the other hand, a strand of environmental literature has used the tools provided by the inequality measurement approach like Heil and Wodon (1997); Hedenus and Azar (2005); Duro and Padilla (2006) or Cantore (2011), among many others.

However, far less attention seems to have been paid, in this context, to the analysis of the degree of international distribution mobility (Nguyen-Van, 2005; Ezcurra, 2007; Herrerías, 2012), which is also fundamentally different from the other distributive approaches. The point is that mobility analysis complements the analysis of inequality/convergence in order to have a broader

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perspective of what happens in the international distribution of emissions, regardless of whether the annual inequality/convergence rises or falls.

Why is mobility an essentially different concept to the traditional inequality approach? Imagine, for instance, a world made up of two fictitious countries. One country emits a large amount of CO_2 per capita into the atmosphere, while the other emits none. Now imagine that, at some point in the future, the countries switch positions: the first country stops polluting and the second one starts polluting as much as the first one had previously. In such a scenario, if we automatically applied an inequality or convergence measure (such as the Gini coefficient, the Theil indexes or the sicma-convergence)[1] we would find that the degree of dispersion is the same in both periods, despite the point that the distribution is, in fact, highly mobile and dynamic. Hence, this type of mobility could, for example, be associated with apportioning environmental responsibility to countries more equitably over a period of time, something that inequality measures are unable to do adequately. Therefore, we might infer that two distributions with broadly the same degree of observed inequality but different degrees of mobility could generate different reflections on their distributional 'qualities', favouring—all other things being equal—the more mobile and dynamic one.

In this regard we can stress the existence of two complementary approaches to mobility distribution as far as the empirical approach is concerned. Firstly, there is the dynamic of the distribution approach which, typically, characterises the internal distributive dynamics through transition matrices, which report the likelihood that observations in certain distributional states will move or not compared to the rest. The discrete transition matrices, using predefined distributive states, work towards producing kernel stochastic estimates (Quah, 1996) in order to provide a continuous reconstruction of the transition processes. Concerning this approach and international distributions of CO_2, we have contributions like those of Nguyen-Van (2005), Ezcurra (2007) and Herrerías (2012). The other major approach, complementary to the one just described, would be to measure mobility through different summary measures associated with different ways of perceiving mobility (the synthetic mobility measurement approach), one of those being that which has been described above. This approach implies a cardinal measurement of mobility as well as giving greater attention to various underlying components and concepts, aspects that are not adequately addressed by the dynamic approach.

The synthetic measurement approach, which represents the main focus of the paper, has as one of its main references, the excellent work produced by Fields (2007). This author suggests, in particular, that there are several ways to measure mobility, depending on the mobility concept employed. According to Fields, five different types of measures can be used for measuring the extent to which the distribution of a particular variable (per capita CO_2 emissions in our case) shifts over time. That is the position/ranking measures (King, 1983), which are related to the aforementioned two countries example; long-term equaliser measures (Shorrocks (1978a, 1978b); relative measures (share changes); non-directional measures (Fields and Ok, 1999) and directional measures (Fields and Ok (1999)).

In fact, and in general terms, the literature focussing on the various possible decompositions of mobility indices (Van Kerm, 2004) suggests that mobility can be explained by three components: first, mobility attributable simply to changes in the variables due to overall growth (growth component); second, mobility attributable to changes in position (exchange component), which is related to the concept of positional indices; and third, mobility due to variations in distribution shape that lead to either more or less inequality (dispersion component).

To our knowledge, no study has fully measured the degree of mobility within the international environmental distribution, at least using the synthetic approach. The main objective of this paper, then, is to analyse the mobility of the international distribution of per capita CO_2 emissions basically using mobility indices related to the aforementioned notions for the period 1970–2007. We will mainly examine the evolution of this mobility, the pattern disparities according to different measures, the degree of synchrony with the evolution of distributional inequality and the role of the various attributed components in explaining overall mobility. Also we decompose the mobility indices to identify the role of developed countries in explaining the patterns.

The rest of the paper is organised as follows. In Section 2, we review the main methodological issues associated with the measurement of mobility by means of synthetic indices. In Section 3, we present the main results obtained by using various different mobility measures and tools to analyse the international distribution of CO_2 emissions and its dynamics. Finally, in Section 4, we summarise our main conclusions and implications.

2. Methodology

In order to measure a distribution's degree of mobility and determine how this feature has evolved over time in the case of international per capita CO_2 emissions, we refer to the classification proposed by Fields (2007). First, various positional movement measures—that is, those which explore the degree to which observations change position over time—have been proposed in the literature. Thus, positional movement measures are related to ranking observations and tracking changes in position. They are therefore sensitive to the degree of concentration of observations at various distributional levels. Among the most widely applied positional movement measures is the one proposed by King (1983). This measure strictly captures ranking-related effects on mobility. Specifically, the formula compares the initial international distribution of per capita emissions "e", where $e=(e_1,\ldots, e_n)$, with a fictitious distribution "z", $(z=(z_1,\ldots, z_n)$, where, if the observations undergo no changes in position, then $z_n=e_n$. If, conversely, an observation occupies position "a" at the beginning of the period and position "b" at the end, then $z_a=e_b$. Therefore, the movement of an observation "i" (a country, in our case) over the course of the period is measured by the following expression:

$$K_i = \frac{|z_i^2 - e_i^2|}{\mu^2} \tag{1}$$

Hence, we can deduce an aggregate mobility index M_K:

$$M_k = \sum_i p_i K_i \tag{2}$$

where "p_i" is the relative population of country "i".

The minimum value of the measure is 0. Its maximum value depends on the sample and the length of the time interval considered.[2] In any case, because it is sensitive only to changes in ranking and depends heavily on the concentration of observations, it would be interesting to consider other perceptions of mobility. Also, given that in expression (1) the differences are expressed in

[1] See, for example, the referential survey by Cowell (1995) which is related to the inequality approach or the influential work of Barro and Sala-i-Martin (1992) in terms of the standard convergence approach. Islam (2003), in fact, produced a survey of the different econometric approaches related to convergence analysis.

[2] In any case, values greater than 1 indicate high mobility.