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International inequality of environmental pressures: Decomposition and comparative analysis

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ABSTRACT

Natural resource scarcity is no longer merely a remote possibility and governments increasingly seek information about the global distribution of resource use and related environmental pressures. This paper presents an international distributional analysis of natural resource use indicators. These encompass both territorial (national production) and footprint (national consumption) indicators for land-related pressures (human appropriation of net primary production, HANPP, and embodied HANPP), for material use (domestic material extraction and consumption and material footprint), and for carbon emissions (territorial carbon emissions and carbon footprints). Our main question is "What, both from a territorial and a footprint perspective, are the main driving factors of international environmental inequality?". We show that, for the environmental indicators we studied, inequality tends to be higher for footprint indicators than for territorial ones. The exception is land use intensity (as measured by HANPP), for which geographical drivers mainly determine the distribution pattern. The international distribution of material consumption is mainly a result of economic drivers whereas, for domestic extraction, demographic drivers can explain almost half of the distribution pattern. Finally, carbon emissions are the environmental pressure that shows the highest international inequality because of the larger contribution of economic drivers.

1. Introduction

Natural resource scarcity is no longer a remote, hypothetical possibility. Today, global human economic activities require more natural resources than ever before: globalization connects distant regions of the world through trade flows, and emerging economies claim their part of the natural resource pie in order to support their economic growth (UNEP, 2011; Wiedmann et al., 2015). International competition for the control of more or less scarce natural resources use has sharply increased (Schaffartzik et al., 2013; Giljum et al., 2014b). The ongoing combination of resource depletion and increased international competition brings distributional issues of natural resources to the top of the agenda.

Recent decades have seen a flourishing of research interest, both in the development of new environmental indicators and in the improvement of traditional ones. In particular, some environmental indicators can be approached both on a territorial basis (environmental pressures within national boundaries) and on a footprint basis (pressures anywhere on earth related to national consumption) (Peters, 2008). This is the case for CO_2 emissions (territorial vs. consumption-based emissions), material flow indicators (domestic extraction vs. domestic material consumption vs. material footprint), and land use intensity indicators (HANPP,

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vs. embodied HANPP).[1] Many studies suggest that reductions of territorial environmental pressures in developed countries are at least partially related to increasing imports from developing and emerging economies (Peters et al., 2011). The availability of robust trade-adjusted environmental indicators allows a more comprehensive analysis of resource use distribution and consequently provides additional insights for global environmental governance. The first aim of this article is to compare the international inequality of territorial-based indicators with that of footprint-based indicators. The results shed light on the role of international trade in environmental equity issues, as well as giving greater insight into the environmental indicators themselves.

There have been many studies that consider distributional issues related to resource use and related ecological pressures. The topics and indicators investigated range from the distribution of CO_2 emissions (Strazicich and List, 2003; Nguyen Van, 2005; Aldy, 2006; Padilla and Serrano, 2006; Duro and Padilla, 2006; Ezcurra, 2007; Criado and Grether, 2011; Cantore, 2011; Steinberger et al., 2012), to energy efficiency distribution (Alcántara and Duro, 2004; Miketa and Mulder, 2005; Duro et al., 2014), of the ecological footprint (Dongjing et al., 2010; White, 2007; Wu and Xu, 2010; Duro and Teixidó-Figueras, 2013; Teixidó-Figueras and Duro, 2014, 2015a, 2015b), material flow indicators (Steinberger et al., 2010; Bruckner et al., 2012; Steinberger et al., 2013; Giljum et al., 2014a; Wiedmann et al., 2015), water (Chen and Chen, 2013; Hoekstra and Mekonnen, 2012) and land (Bruckner et al., 2015; Weinzettel et al., 2013; Yu et al., 2013). These analyses provide information on how resource use is currently shared among nations. They discuss equity issues involved in sustainability concepts or policy implications where resource inequality might play a critical role. These include climate change negotiations for CO_2 studies or political economy involved in trade relationships for material flows indicators or Ecological Footprint (Moran et al., 2013). But, why do these international inequalities in resource use among countries exist? And why are some environmental pressures more unequally distributed than others? The second aim of this article is to answer these two questions by analysing the drivers of environmental pressures.

We use the term "drivers" to describe the range of factors that may influence the distribution of environmental pressure indicators across countries: drivers can be socio-economic (income, trade), geographical or historical (climate, population density), demographic (urbanization), or biophysical (resource endowment) (Rosa and Dietz, 2012). The study of drivers of environmental pressures has been of widespread interest to researchers and policy makers. Typically, by the use of multiple linear regressions (York et al., 2003a; York et al., 2003b), these analyses reveal a driver's elasticity (β coefficients in the regressions), and the amount of variability in their indicator captured by all drivers taken together (R^2 statistic). Consider the case where an environmental pressure can be explained by selected drivers, such as income and climate, for example. It then stands to reason that we can expect the inequality in its distribution to be related not only to the inequality of these drivers, but also to the strength (elasticity) with which these drivers are coupled to the environmental pressure. In this analysis, we apply a method which allows us to perform this decomposition (Fields, 2003; Teixidó-Figueras and Duro, 2015b): it explains international inequality in environmental pressures in terms of the inequality and strength in the driving components of these pressures.

Hence, the objective of this study is firstly to analyse the international inequalities of a set of environmental indicators, with special emphasis on comparing the distribution of territorial and footprint indicators and, secondly to decompose the inequality of the indicators in terms of their drivers. The analysis is applied to three families of environmental indicators, each family consisting of a territorial indicator and a footprint indicator. The first family covers land use intensity: Human appropriation of net primary production; HANPP, (Krausmann et al., 2009), and embodied HANPP; eHANPP (Erb et al., 2009; Haberl et al., 2012). The second family covers three indicators related to material use: domestic extraction; DE, domestic material consumption; DMC (Krausmann et al., 2008), and the material footprint; MF (Wiedmann et al., 2015). The third family refers to carbon emissions with territorial CO_2 emissions and consumption-based CO_2 emissions (Peters and Hertwich, 2008; Boden et al., 2013).

2. Materials and methods

Our comparative analysis proceeds in three stages: first, we calculate the distribution dispersion through inequality indices to determine unambiguously the distribution pattern of environmental indicators and determine which of those are the most unequally distributed. In a second stage, we estimate linear regressions in order to determine the relationship between proposed drivers and the environmental indicators considered. In a third stage, we decompose the inequality measured in stage one in terms of the drivers estimated in stage two. Such information might be critical for policy making, since it could indicate where the source of the total inequality lies and at the same time which drivers are more important in determining the variability of environmental indicators.

Territorial (or production-based) indicators refer to the environmental pressures taking place within national (including administered) territories and offshore areas over which the country has jurisdiction, whereas footprint indicators (or consumption-based) add imports to, and subtract exports from, territorial indicators (see Peters, 2008). All data refers to the year 2000, the only year for which all indicators were available and accessible. This analysis is entirely novel, since very few studies have done comparative analysis across different resources/indicators and even fewer have considered both territorial and footprint indicators. The research question of our analysis is not particularly time-specific, but focuses on a comparative view of a broad set of environmental indicators revealing fundamental differences. The basic findings of this analysis, therefore, are of current significance, despite the focus on the year 2000. It is also clear, however, that given the major changes in the global economy since 2000, in particular the rising significance of emerging economies in global resource use, the observed patterns in global inequalities may have changed since 2000 (Wiedmann et al., 2015; Schaffartzik et al., 2013; Giljum et al., 2014a; Giljum et al., 2014b). This may encourage future research in this issue when further data is available. The countries sampled comprise between 88–97% of the world population, depending on the availability of data for each indicator considered (see Table 1). As in Steinberger and Roberts (2010), countries are weighted by their population, so that global population is better represented in both inequality measurement and regressions.

2.1. Environmental indicators

In this section, in order to allow the reader a proper interpretation of their international distribution, we briefly describe the

[1] There are other environmental indicators that also consider the territorial versus footprint dichotomy whose inclusion to the analysis would certainly be of interest (see Arto et al., 2012). This is the case of virtual water (Chen and Chen, 2013; Hoekstra and Mekonnen, 2012) or other land area indicators (Bruckner et al., 2015; Weinzettel et al., 2013; Yu et al., 2013). However, the set of indicators used was chosen reflecting the availability of data and their accessibility to the authors.