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The international distribution of energy intensities: Some synthetic results

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HIGHLIGHTS

- International inequalities and polarization in energy intensities are examined.
- The reduction on energy intensity levels has coincided with a reduction in cross-country inequalities.
- Cross-country energy intensity inequalities are basically a question of regional groups.
- The increase in bi-polarization incorporates problems in terms of environmental agreements.
- The results obtained have useful policy implications

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ABSTRACT

The paper examines the international distribution of energy intensities as a conventional proxy indicator of energy efficiency and sustainability in the consumption of resources, by employing some descriptive tools from the analysis of inequality and polarization. The analysis specifically focuses on the following points: firstly, inequalities are evaluated synthetically based on diverse summary measures and Lorenz curves; secondly, different factorial decompositions are undertaken that assist in investigating some explanatory factors (weighting factors, multiplicative factors and decomposition by groups); and thirdly, an analysis is made of the polarization of intensities when groups of countries are defined endogenously and exogenously. The results obtained have significant implications from both academic and political perspectives.

1. Introduction

The uncoupling of energy consumption and economic growth plays a crucial in achieving a carbon-free society. Thus, for example, based on the European Union Energy Roadmap 2050 (European Commission, 2011), the continental objectives of reducing emissions by 80% by 2050 imply, in all working hypotheses, the need for substantial improvements in energy efficiency and hence for reduction in the consumption of resources, not only in relative terms but, most importantly, in absolute terms. In fact, the necessity for reducing consumption in absolute terms (as a strong condition) and for making this compatible with economic growth implies considerable progress in energy intensities.[1] In such circumstances, the analysis of this indicator, and its international distribution, are a subject of academic and political interest.

Energy intensity, as a broad environmental indicator can, in fact, be interpreted based on a variety of factors (Steinberger and Krausmann, 2011). Firstly, in accordance with the classical environmental impact descriptive models IPAT and STIRPAT (Ehrlich and Holdren, 1971), intensity can be associated with technology. Based on this, the environmental impact on a system (I) is the product of multiplying population factors (P), affluence (A) and technology (T). In this context, technology would attempt to balance out the requirements and excesses attributable to the demands on resources by the population and the economy. Secondly, the intensities can be interpreted in terms of the sectorial structure and its changes. Thus, this indicator can change as a result of changes in the composition of production in favor of sectors that consume more or less energy (Schäfer, 2005). Thirdly, this indicator, being linked strictly to the demand for resources (in this case energy), is associated with a concept of sustainability and reflects, for example, the relative decoupling between the

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[1] Obviously, then, improvements (i.e. reductions) in energy intensity are a necessary but not sufficient condition for achieving a strong sustainability. Strong sustainability would require a reduction in global consumption and consumption would need not merely to be inelastic to GDP growth, but to have negative elasticity (see Böhringer and Jochem, 2007).

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economy and the consumption of resources. In a world which, in principle, has finite energy resources, endless economic growth is only possible if energy intensity is significantly reduced. Therefore, the analysis of this indicator is interesting insofar as it relates to the sustainability of the endless development model and the demand for energy.

However, beyond the analysis of intensity levels, it may be interesting to examine how this indicator is shared between countries. In this sense, the analysis would be related to the literature on international environmental equity (Daly, 1992). In fact, in the environmental field, analysis of the international distribution of indicators has recently been attracting much interest. Technically, the analysis of international environmental distribution has relied on two major approaches, complementary in terms of the subject under study but differing in the tools employed. Firstly, a series of studies have used convergence analysis based on the suggestive works of Barro and Sala-i-Martin (1992) and Quah (1996a,b), which focus on the basic use of σ- and β-convergence techniques. Secondly, there are studies that use tools developed in the analysis of inequality (Cowell, 1995), which typically examine distributions with a cross-section focus (similar, in fact, to that used in the analysis of σ-convergence), which have usually concentrated on the properties of the measurements and the possibility of their decomposition.

Environmental distribution analysis has been applied to indicators such as CO_2, the carbonization index, emissions intensity (CO_2/GDP, the environmental footprint and the consumption of materials (Hedenus and Azar, 2005; Duro and Padilla, 2006; White, 2007; Jobert et al., 2010; Duro et al., 2010; Steinberger et al., 2010; Cantore, 2011; Duro, 2012; or Camarero et al., 2013)). In particular, the analysis of the international distribution of energy intensities is of interest, both academically and in terms of policy, for the following reasons: firstly, because it helps in understanding the sharing of effort between countries in terms of relative resource consumption, and, therefore, in analysing the degree of differential responsibility within the overall context. Specifically, a situation where intensities are reduced globally, but at the cost of widening the gaps between countries, has different implications to the generally preferable situation in which the global change includes a narrowing of the inter-country gaps. Secondly, decomposition analyses can address some explanatory factors and may also have some useful policy implications. For example, as we will see, the decomposition of inequality by groups of countries (regional groupings, or by level of development) can be used as a guide for a global design of policy and strategies aimed at reducing inequality. Finally, analysis of polarization (Esteban and Ray, 1994 and Esteban et al., 2007), which is a distributive concept essentially different from inequality, seems the best approach for understanding the possibility of the materialization of international conflicts implicit in the situation – this being an aspect of great importance for current global trading scenarios. Knowledge of the degree of energy intensity polarization around poles of distant countries, and also the factors that characterize these, can be useful in guiding reductions in polarization, in alleviating the inherent distributive conflict and, thus, in increasing the chance of reaching international agreements related to this environmental target.

In terms of the literature, international distributive analysis in terms of energy intensities has relied on contributions such as those of Sun (2002), Alcántara and Duro (2004), Markandya et al. (2006), Ezcurra (2007), Duro (2012) and Herrerías (2012). Sun (2002) analysed a reduction in the inequality of energy intensity between countries in the Organization for Economic Co-operation and Development (OECD) by considering deviations from the mean. Alcántara and Duro (2004) used the Theil index, which weights observations according to GDP and gives greater importance to those countries with a greater share of global production. Markandya et al. (2006) used convergence-type analysis to confirm the relationship between energy intensities and income convergence for the countries of Eastern Europe, finding a positive ratio between the convergence of the mean European income (increase) and convergence in intensities (decrease). Ezcurra (2007) analysed inequalities in energy intensities between 1971 and 2001 using non-parametric techniques. Duro et al. (2010) analysed the role of intensities in explaining the difference in consumption per capita based on multiplicative inequality decompositions for 1980–2006. Duro (2012) analysed inequalities in energy intensities using different summary indices for the period 1971–2006 (without carrying out any decomposition analysis); Herrerías (2012) analysed the distribution of intensities between 83 countries during the period 1971–2008 based on dynamic distribution techniques. In light of the previous literature, this paper aims at extensively exploiting the analytical possibilities related to different decompositions, at carrying out a polarization analysis, and at updating the calculations to the period 1990–2011 and for a greater number of countries (137).

In particular, this paper will provide a detailed study of the different distributive analysis instruments available for the exploration of energy intensities. Thus, we can highlight the following differential contributions: firstly, a standard inequality analysis is performed in parallel with a variety of decompositions. Specifically, the paper distinguishes the importance of weighting factors as opposed to a vector of intensities in order to explain global inequality. It makes intensive use of the possibilities associated with the decomposition by country groupings (by regions, or by levels of development); the work additionally includes different multiplicative decompositions for analysing the role played by different factors. Secondly, a polarization analysis is applied to energy intensity based on both endogenous and exogenous techniques. This concept is very useful in terms of understanding both potential instability and the probability of reaching certain agreements on the world stage.

The paper is therefore structured in the following way: the second section provides a review of a variety of methodological aspects of interest relative to the measurement of inequality, its decomposition and the analysis of polarization. The third section presents the main results associated with the implementation (using an extensive territorial coverage and different groupings) of the aforementioned techniques and instruments in the analysis of international inequalities in energy intensities in the period 1990–2011. Finally, there is a section that brings together the main considerations arising from these analyses.

2. Methodological aspects

Intensity in the consumption of resources is thus a highly important objective in guaranteeing the sustainability of the planet and in being able to balance economic growth with environmental sustainability. This study addresses the international distribution of this indicator. Although different distributive dimensions exist, the main one analysed thus far concerns inequality (or convergence if preferred). The main methodological elements of interest in respect of the initial focus come from the literature on *inequality measurement* (Cowell, 1995).

The first essential aspect concerns synthetic measurement. In this respect, the literature describes indicators that are consistent with the Lorenz dominance criterion.[2] Duro (2012), for example,

[2] In other words, indices that are consistent with ordering distributions based on Lorenz curves. In fact, Lorenz curves associated with different distributions