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The CO_2 emission Gini index and the environmental efficiency: An analysis for 60 leading world economies

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Abstract

The aim of this study was to analyze the CO_2 emission Gini index and the environmental efficiency for 60 leading world economies, in 2010. We consider the technological heterogeneity dividing the sample into similar groups, and estimating environmental efficiency indicators into metafrontier and group frontiers. Despite the fact that pollution concentration is more prominent in developed countries, the results showed that this group is more efficient. On the other hand, lower-income group, and medium-technology countries present the worst indicators. We could conclude that the inefficiency observed in developed countries group was attributed to mismanagement, while in the developing countries group the inefficiency could be related to technological differences.

JEL classification: C61; O57; Q54

Keywords: Environmental efficiency; Metafrontier; Pollutants; Gini index

1. Introduction

The ever-growing attention to the environment is not only related to social concern regarding the exhaustion of natural resources, but also to the capacity of the planet to absorb the pollutants generated by human being. According to studies conducted by the World Bank (2015), between 1960 and 1990, environmental indicators deteriorated greatly due temperature increase via the Greenhouse effect (GHG). The carbon dioxide (CO_2) emission through fossil fuel has been responsible for approximately 56.6%.

The United States of America (USA) are at the top when it comes to the pollution ranking, being responsible for about 30% of the world emission between 1970 and 2010. Then, with 13%, comes China, followed by Japan (5.97%) and the United Kingdom (3.69%). It is possible to see that around 70% of CO_2 emission is derived from ten countries (also including India, Russia, France, Canada, Italy and Poland). Another important factor is that, out of the ten greatest emitters, seven are also on the list of countries with the largest GDP – the USA, Japan, France, the United Kingdom, Italy, China, and Canada – indicating a dependence relation between production and pollution emission (World Bank, 2015).

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To create effective environmental policies regarding this issue, several researches have been made in order to analyze the relationship between productive process and CO_2 emission (Grossman and Krueger, 1991; Panayotou, 1993; Selden and Song, 1994; Iwata and Okada, 2014). The main pieces of evidence suggested that there is a relation following an inverted U format, a behavior that is similar to Kuznets's (1955) assumption, regarding the economic growth effect on income inequality. The Environmental Kuznets Curve (EKC), as it was known after Grossman and Krueger (1991), suggests that the environmental degradation rate could increase during early development, due to the income expansion necessity at this moment. Nevertheless, it grows progressively less until maximum peak, where it reverses the behavior. This path was attributed to consumer satiation, the socioeconomic indicators evolution, the increasing environmental restrictions, and the social environmental consciousness.

Despite the fact that EKC has been widely used, we can see that its functional form takes undesirable output (pollution) as a function of the desirable output (production). Nevertheless, Färe et al. (1996) demonstrate that productive process could generate two outputs: the desirable and the undesirable output. Furthermore, as remarked by Zhou et al. (2010), EKC function could not distinguish good production practices from other intensive pollution methods. This analysis could be useful because it provides information about resource allocation, including the natural ones.

Several studies have been conducted in order to relate desirable and undesirable outputs as products through frontier models (Zhang and Choi, 2013). According to Chiu et al. (2012), these models could generate environmental efficiency indicators, which show the best relationship between production and pollutant emission. This indicator could determine how close a unit, as a country, is from efficiency frontier, as well as how much pollutant's reduction is necessary for it to be efficient. Therefore, we could analyze the trade-off between production and environmental conservation by using the production theory (Kuosmanen and Kortelainen, 2005).

Conceptually, we should consider only homogeneous units to apply the production theory on environmental efficiency analysis. However, this restriction cannot always be obeyed, because it could exist heterogeneity among countries caused by socioeconomic variables and technological differences. We could not presume that lower-income countries are over the same technological frontier as development countries (Chiu et al., 2012). For this reason, O'donnell et al. (2008) suggested dividing the sample into k subgroups, following technological criteria previously established, and to attribute a part of the environmental inefficiency to technological gap between frontiers and another part to mismanagement. This methodology was named metafrontier analysis. Nevertheless, there is not a compelling criterion in the literature about how to group countries according to technological level. In addition, we could apply some technological proxies to construct groups, as high technological products exportation, and research and development expenditures. These variables could be crucial to formulate groups in the same technological levels. However, these criteria were not applied yet.

Therefore, this study aims to analyze the environmental efficiency of the largest world economies, controlling the heterogeneity amongst countries, estimating production frontier with desirable and undesirable products. This approach allows the identification of countries that are on metafrontier and on group frontiers. Cluster analysis was used to group the countries into similar frontiers. In addition, the CO_2 emission Gini index was calculated in order to give empirical support to the environmental efficiency indicators, showing the pollutant concentration degree.

This paper is organized as follows: In Section 2 it is introduced the environmental efficiency theoretical model used in this paper. The analytic framework is presented in Section 3, showing the metafrontier and group frontiers models. The analysis results are shown in Section 4. Finally, in Section 5 this paper's conclusion is summarized.

2. The production technology for desirable and undesirable products

The production of goods that improve social welfare could be associated with other products that society does not wish for, such as pollution. Because these goods are produced jointly in the production process, the country faces the trade-off between productive expansion and environmental conservation (Coase, 1960; Zhang and Choi, 2013). Formally, a desirable output could be denoted as $y \in \Re_+^M$; an undesirable output, as $b \in \Re_+^I$; and the inputs, as $x \in \Re_+^N$. The desirable and undesirable sets are compact and closed, *i.e.*, finite amounts of input produce finite amounts of goods (Färe et al., 2005). That said, the general production technology is described according to the following expression (1a).

$$P(x) = \{(x,y,b) : x \text{ can produce } (y,b)\}. \tag{1a}$$

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