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A NEW INDEX OF ENVIRONMENTAL QUALITY

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Overview

There are already some indicators and descriptive statistics in environmental accounts (see United Nations, 2003). The system of national accounts (SNA) includes stocks of natural resources, pollutant and material (energy) flow accounts at the industry level, expenditures incurred by industries, government and households to protect the environment. Assets are evaluated either as net present value or net price.

Several macroeconomic indicators measuring some aspects of the environmental quality of a country have been elaborated. The environmentally adjusted net domestic product (eaNDP) is obtained by combining the conventional NDP with monetary values of environmental degradation (Repetto et al. 1989). From national accounting matrix including environmental accounts (NAMEA) single indicators are obtained for different themes (e.g. acidification of the atmosphere, eutrofication of waters etc) by aggregating the emissions, using some common measurement unit and then comparing them with a national target level. The NAMEA, however, does not provide a single-valued indicator that aggregates across all themes. A single-valued indicator of total material requirements (TMR) can be derived from SNA, which sums all the material use in the economy by weights, to measure dematerialization. Many researchers have criticized eaNDP for mixing actual transactions with hypothetical values (monetary values) of environmental degradation; as a response, the indicators geNDP and SNI have been elaborated. Greened economy net domestic product (geNDP) estimates national income in a hypothetical future in which the economy must meet certain environmental standards and the impact is estimated by internalizing the costs of reducing environmental degradation (for a hypothetical model, see De Boer et al, 1994; the Swedish National Institute of Economic Research, 2000). Sustainable national income (SNI) estimates the maximum level of national income that would be obtained if the economy met all environmental standards using the current technology (see, for example, Verbrugger et al. 2000).

Although the above mentioned indicators and descriptive statistics have been provided in environmental accounts, there is no consensus over which indicators to use. Moreover, each indicator serves a somewhat different policy purpose. Finally, the above-mentioned indicators are often based on arbitrary weighting of the relevant variables. Thus, a construction of an index of environmental quality is all-important.

Method

In this paper we construct an aggregate index for the environmental quality of a country based on stochastic dominance (SD hereafter) analysis. Constructing an index based on SD analysis has advantages since the index will be efficient, in that it results from the least variable combination of risk factors that offers the maximum level of risk over time for each country or group of countries and relatively large data sets are available, so that nonparametric analysis can let the data speak for themselves. The index is constructed in a way such that the weights given to each risk factors in each sub-index will make it stochastically dominate all other competitor indices.

The methodology employed in this paper is based on multi-variate (multidimensional) comparisons of country panel data over various years. In an application to optimal portfolio construction in finance, Scaillet and Topaloglou (2010) use SD efficiency tests to compare a given portfolio with an optimal diversified portfolio constructed from a set of assets. In this paper, our main objective is to derive an optimal index for the environmental quality of a country based on SD analysis with differential component weights. This index will offer the maximum level of risk in a country for a given probability level and also be the least volatile over time among its set of competitors.

Results

First, the stochastic efficient weighting for each set of variables is calculated to build three sub-indices (for greenhouse emissions, water pollution and land without forests) and then an overall risk index of environmental quality is constructed. We find that CO_2 is the main contributor to emissions with a 80% contribution followed by methane 18%, whereas nitrous oxide and other greenhouse gas emissions have minor contributions. Moreover, we examine water pollution by measuring the organic water pollutant emissions (kg per day) expressed as percentage of organic water polluted by specific industries. If other industries were removed, then food industry and textile industry would contribute with 75% and 21% respectively. The main result is that land without forest contributes the most (with around 70%), greenhouse emissions contribute with around 20% and water pollution contributes less (with around 10%). Finally, countries are ranked according to their index of environmental quality and their rankings are compared with those of the Kyoto Protocol.

Conclusions

In this paper we propose an optimal weighting scheme to construct a new index of environmental quality for different countries using an approach that relies on consistent tests for stochastic dominance efficiency. The test statistics and the estimators are computed using mixed integer programming methods. The variables that are considered include countries' greenhouse emissions, water pollution and forest benefits, as from the dataset of the World Bank.

For future application, this methodology could be applied to find the optimal composite index representing a most appropriate measure of wealth for a country. One could find the weighting scheme of each sub-index (i.e. of environmental quality, of natural resources, and HDI) which corresponds to the overall riskiest case for the countries. As Hamilton and Clemens (1999) state, "thinking about sustainable development and its measurement leads naturally to a conception of the process of development as one of portfolio management". This implies that one has to consider not only assets and liabilities in the national balance sheet (i.e., natural resources, produced assets, human capital and pollution stocks) but also their appropriate weights.

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