An Investigation on the Factors That Affect Carbon Dioxide Emission Changes: An Application of Logarithmic Mean Divisia Index

Huang, Bwo-Nung, National Chung Cheng University, Chiayi, Taiwan ecdbnh@ccu.edu.tw
Yang, Chine-Wei, Clarion University of Pennsylvania, USA Yang@mail.clarion.edu

Overview

There is no denying that increasing emission of green house gases has impacted world climate significantly. Even though the Kyoto Protocol (KP) held in December 1997 capped future emission levels for the member (developed) countries, its impact is rather limited. The Congress of the United States (the largest carbon emitter) never approved the Kyoto mandate. Other major producers such as China and India were not among developed countries and as such are not subject to the caps set by the KP. Consequently, global emission of carbon dioxide has not been on the decline and it is little wonder that global warming becomes a serious problem to be tackle.

However, factors leading to CO_2 emissions are country-specific. As a result, one must investigate factors in each country that lead to excess emissions. One-size-fits-all policy is neither practical nor feasible. The objective of this proposal is to decipher and identify factors that contribute to changes in carbon emission via using the logarithmic mean Divisia index (LMDI)。

Method

Literature abounds in decomposition method on CO_2 emission or energy consumption. Please refer to the paper by Ang and Zhang (2000). Furthermore, Ang (2004) points out that both the LMDI and revised Laspeyres index are among the best decomposition methods because they produce no residuals and are computationally efficient. In particular, the LMDI has become most utilized method in the literature. Hence, we intend to apply the same methodology to each country from 1971 to 2008. Let C_i be CO_2 emissions emanated from fossil fuel consumption for country i, FFC_i be fossil fuel consumption for country i, TEC_i be total energy consumption for country i, GDP_i be gross national product for country i and POP_i be population size for country i。 Given the notations, it can be shown the CO_2 emission for country i can be partitioned into the following:

$$\begin{aligned} C_i &= \left(\frac{C_i}{FFC_i}\right)\left(\frac{FFC_i}{TEC_i}\right)\left(\frac{TEC_i}{GDP_i}\right)\left(\frac{GDP_i}{POP_i}\right)POP_i, \\ &= X_{1i}\cdot X_{2i}\cdot X_{3i}\cdot X_{4i}\cdot X_{5i} \end{aligned}$$

where X_{1i} represents CO_2 emitted from consuming one unit of fossil fuel or the coefficient effect;
X_{2i} is the ratio of fossil fuel consumption to total energy consumption, also known as substitution effect;
X_{3i} is the amount of total energy used in producing one dollar worth of GDP or energy intensity or strength;
X_{4i} is per capita GDP_i and
X_{5i} denotes population size for country i.

The LMDI decomposition method has two versions: multiplicative and additive models. For the multiplicative model, we have the following:

$$D_{tot} = \frac{C^T}{C^0} = D_{x1} \cdot D_{x2} \cdot D_{x3} \cdot D_{x4} \cdot D_{x5} ,$$

where superscript T and 0 represent period T and base period respectively.

The additive model takes the following form :

$$\Delta C = C^T - C^0 = \Delta C_{x1} + \Delta C_{x2} + \Delta C_{x3} + \Delta C_{x4} + \Delta C_{x5} .$$

In which

$$D_{Xk} = \exp(\sum_i \frac{(C_i^T - C_i^0)/(\ln C_i^T - \ln C_i^0)}{(C^T - C^0)/(\ln C^T - \ln C^0)} \times \ln(\frac{X_{ki}^T}{X_{ki}^0})) ,$$

$$\Delta C_{Xk} = \sum_i \frac{C_i^T - C_i^0}{\ln C_i^T - \ln C_i^0} \times \ln(\frac{X_{ki}^T}{X_{ki}^0})$$

$k = 1, 2, 3, 4, 5$.

Expected Results

These models will be applied to nearly 100 nations. By using the decomposition models, we expect to obtain factors that contribute to the carbon dioxide emissions country by country. Along with country specific data, we will provide appropriate policy recommendations on carbon reduction for each nation.

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