AN INTEGRATED APPROACH FOR ENERGY EFFICIENCY ANALYSIS IN EUROPEAN UNION COUNTRIES

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Overview

The world energy crisis of 1993 brought energy efficiency into the policy agenda of many countries as a top priority issue. With the more recent understanding of the need to act against global warming and climate change, it has become a much more important concept. Energy efficiency is said to be one of the "twin pillars" along with renewable energy, of a sustainable energy policy. Improvements in energy efficiency can reduce the need for investment in energy infrastructure, cut fuel costs, increase competitiveness, increase energy security by decreasing the reliance on imported fossil fuels, while at the same time help save the environment by reducing greenhouse gases emissions and local air pollution. Energy efficiency is still a promising strategy to conserve energy without slowing down economic growth. Had efficiency improvement been stagnant in the past, we would have seen much higher demand creating a more pressing need for energy supply. What is more, enhanced energy efficiency reduces energy consumption and CO2 emissions even without a climate policy, though it can be costly and take time to realize (Huntington and Smith, 2011). These "baseline" reductions can go a long way towards meeting climate policy targets, particularly in the short term (Murphy and Jaccard, 2011).

As McKibbin et al. (2011) point out, adoption rates for energy efficient technologies fall short of levels that many believe are justified by the potential returns on such investments. Therefore, the re-evaluation of the connections between energy efficiency, growth, and economic performance, is of major importance and has direct implications for the policies implemented at the country level. The objective of this study is to introduce and apply an integrated decision support methodology for this purpose, using up-to-date data from European Union countries.

Methods

In an integrated context, the evaluation of energy efficiency is a multidimensional issue. Thus, the proposed approach is based on the consideration of data related to environmental performance and pollution, country characteristics, information on the use of renewable sources and the composition of the energy mix, as well as energy consumption and production data. What is more, this paper takes into account the undesirable factors such as waste water, waste gas and solid wastes. Since the early 1990s, several accounting systems for tracking economy-wide energy efficiency trends have been developed to give energy efficiency indicators that could replace the primary energy consumption to GDP ratio, as the latter is not a good indicator for tracking economy-wide energy efficiency trends. Ang et al. (2010), have proposed some specific methodological and application issues in tracking economy-wide energy efficiency trends, serving as a guide to researchers and analysts interested in the development and application of an economy-wide energy efficiency system. The estimates for the core energy efficiency using a full frontier model show that for a number of countries the change in energy intensity might give a reasonable indication of efficiency improvements, although this is not always the case both over time and across countries. Thus, the framework adopted in this paper attempts to isolate the "underlying energy efficiency" for each country after controlling for income, price, climate effects, technical progress and other exogenous factors, as well as effects due to differences in area size and the structure of the economy. Consequently, once the latter

effects are adequately controlled for, the estimation of the underlying energy efficiency for each country is performed which shows i) the change of efficiency over the estimation period and ii) the differences in efficiency across the panel of countries (Massimo and Lester, 2011). The evaluation of energy efficiency is based on a non-parametric approach, namely Data Envelopment Analysis (DEA). DEA is a widely used technique for efficiency analysis with many applications in environmental management and energy planning (Zhou et al., 2008). DEA provides efficiency estimates, supports the identification of the sources of inefficiency, as well as the specification of performance targets. This approach can combine several economic and social indicators of nations and provide a holistic analysis of the comparative performance of those countries (Ramakrishnan, 2005). Data Envelopment Analysis (DEA) can be used not only to develop an efficiency index which combines economic activity, CO2 emissions and energy consumption of the production process in countries, but also to make estimates about the margins of long term increase or decrease in the consumption levels of exhaustible energy resources of a selected sample of countries (Bampatsou and Hadjiconstantinou, 2004). In this study a two-stage DEA approach is employed, where the efficiency estimates obtained from the analysis at the first stage are analyzed in a second stage through a multiple criteria decision aiding methodology (MCDA; Diakoulaki et al., 2005), in order to build an operational evaluation model that can be used for benchmarking purposes in a dynamic context.

Results

This study's results have both methodological and empirical contributions and implications. On the empirical side, the use of up-to-date data spanning the period before and after the outbreak of the recent crisis, enables the re-examination of the energy efficiency levels of EU countries during a period of major economic turmoil. In this context, the integration of energy efficiency evaluations with economic performance and growth indicators provide new insights related to the impact of the crisis on energy-related policies and their results. On the methodological side, the proposed non-parametric approach combining DEA with MCDA enables the modeling of the problem in an integrated manner, providing not only energy efficiency estimates, but also supporting the analysis of the main contributing factors, as well as the development of a benchmarking model for ranking and rating the countries.

Conclusions

This study considers the issue of evaluating energy efficiency at a country level in a multidimensional framework, taking also into account the effect of the recent crisis. The proposed non-parametric methodology and the obtained empirical results contribute through the construction of an operational decision support model for energy efficiency evaluation.

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