AN ENERGY EFFICIENCY ANALYSIS IN INDUSTRIAL SECTOR

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Overview

Energy is a basic need for different purposes in industrial facilities around the world. The industrial sector uses more energy than any other end-use sectors, currently consuming about 37% of the world's total delivered energy. Industrial development across the world will result in more energy use and will lead to more concentration of greenhouse gases such as carbon dioxide (CO2) and other emissions such as sulfur dioxide (SO2), nitrogen oxide (NOx) and carbon monoxide (CO) which all have disastrous consequences for the earth's climate like rising temperature, drought, floods, famine and economic chaos. Improving energy efficiency is universally recognised as an important means of reducing greenhouse gas emissions, improving competitiveness, and reducing dependence on depleting fossil fuel resources. The aim of this paper is to analyze the energy efficiency of energy-intensive industries across 26 European countries over the period 2000–2009. Manufacturing, chemicals and chemical products, electricity-gas and water supply, construction, machinery, mining and quarrying and transport are the seven industrial sectors that are examined. The evaluation is based on a non-parametric approach, namely Data Envelopment Analysis (DEA), combining multiple energy consumption data, economic outputs and environmental factors.

Methodology

Researchers in many fields have used various approaches to measure energy efficiency in the industrial sector. These analysis techniques were grouped into four types: energy trend decomposition methods, econometric methods, 'Top–down' and 'Bottom–up' models and industry-specific micro-economic analyses (Clara Inés Pardo Martínez, 2011). On the methodological side, we use data envelopment analysis (DEA) to measure the relative efficiency of seven well-known industries. DEA is a popular nonparametric efficiency analysis technique with many applications in analyzing the energy use efficiency of industrial sectors (see among others, Sarica and Or, 2007; Mukherjee, 2008a; Mukherjee, 2008b; Azadeh et al., 2007). DEA, originally proposed by Charnes et al. (1978), is a nonparametric frontier technique where efficiency of a particular entity is measured by its distance from the best practice frontier constructed by the best entities within a sample. It is a well-established methodology for the evaluation of the *relative* efficiencies of a set of comparable entities (decision making units, DMUs) which transform multiple inputs (energy and non-energy inputs) into multiple outputs (desirable and undesirable). The energy efficiency of each sector is evaluated under constant and variable returns to scale (CCR and BCC model) respectively. The inputs and outputs of DEA provide the socio-economic accounts, including industry output, value added, capital stock, wages and employment by skill type and the environmental accounts including industry energy use, CO2 emissions and emissions to air. The choice of these variables was based on literature review as many studies have used them for measuring the industrial energy efficiency (Clara Inés Pardo Martínez, 2011; Mukherjee , 2008a; Mukherjee, 2008b).

Results

Under constant and variable returns to scale (CCR and BCC model), manufacturing and chemicals are the sectors that present the higher and lower efficiency scores respectively. In particular, the period 2000-2003 is characterized by stable efficiency conditions in most sectors, whereas during 2004-2008 the efficiency trends indicate steady improvement. Finally, in 2009, a decrease is evident in all sectors due to economic crisis. As far as the scale

efficiency, it is consistently lower for the chemicals sector. Machinery and mining are the two sector with the lowest improvements in scale efficiency over the years, whereas considerable gains have been achieved in construction and manufacturing. The environmental variables of air and CO2 emissions seem to be the factors where considerable improvements can be achieved in the sectors of machinery, manufacturing, mining and transport. On the other hand, improvements in gross output and gross value added (economic variables) are important for sectors such as chemicals, electricity, machinery, and mining, whereas the sector of construction should focus on improving the variable of gross energy use. What is more, it is proved that the number of employees and the emission relevant energy use do not affect the sectors' efficiency.

Conclusions

Overall, the results indicate the gradual improvement of energy efficiency of sectors across the examined time and across the EU countries until 2008 and a decreasing trend afterwards. This study's results not only provide a general efficiency ranking and evaluation of the investigated industries, but also facilitate various interesting efficiency comparisons, with respect to factors that have the highest explanatory power. What is more, 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 industries during a period of major economic turmoil.

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