Is Spain More Efficient Than the Other Countries of EU-28? Searching the Answer Through DEA and Malmquist Index

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Abstract

The European Union is one of the blocks of countries in the world that is doing more in the fight against climate change and therefore it has opted to promote the reduction of greenhouse gas emissions. In this paper we analyze Natural and Managerial efficiency of the 28 countries of EU from 2005 to 2013. For this purpose the Malmquist index (MI) has been used, considering crosses on the efficiency frontiers between years and using windows of two years. As input variables, gross capital formation (GCF), final energy consumption, renewable energy consumption and employment have been used. Gross domestic product (GDP) has been taken as desirable output and greenhouse gas emissions as undesirable output. The obtained results indicate that Spain has a similar behavior to the countries that have more time in the EU, both in terms of Managerial efficiency and Natural efficiency.

1 Introduction

The climate of our planet has been undergoing major alterations for several decades. The warming of the Earth is unequivocal and for the most part this is most likely due to the increase in concentrations of greenhouse gases (GHG) caused by human activities such as the widespread use of fossil fuels - oil, gas or coal -, decomposition of urban or cattle waste and changes in land use. Therefore, a significant reduction of GHG emissions [IPCC, 2014] is necessary to limit warming and its negative effects. This need has been widely addressed at the Paris Climate Conference (COP21) in December 2015. In this Conference the EU has played a leading role and in which 195 countries have for the first time adopted a global legally binding global climate agreement. The EU has based part of its strategy on combating climate change in its energy policy with the aim of creating an Energy Union in Europe and thus ensuring that its citizens and their businesses have a secure, affordable and respectful of the climate. Europe stands for a sustainable, low-carbon and environmentally friendly economy that leads the production of renewable energy and the fight against global warming. To this end, different climate and energy objectives have been set for 2020, 2030 and 2050. Targets for 2020: to reduce GHG by 20 %, as compared with 1990 levels; to obtain 20 % of energy from renewable sources and to improve energy efficiency by 20 %. Targets for 2030: 40 % reduction of GHG; at least 27 % of renewable energies; increase in energy efficiency by 27-30 %; 15 % of electricity interconnection (ie 15 % of electricity generated in the EU must be able to be transported to other member states). Target for 2050: 80-95 % reduction of GHG compared to 1990 levels. In this context, environmental assessment is a technique of analysis widely used in the scientific field related to study and prevention of the consequences of

In: Zoe Falomir, Juan A. Ortega (eds.): Proceedings of JARCA 2016, Almería, Spain, June 2016, published at http://ceur-ws.org

climate change in general and of pollution, in particular. This work applies an environmental assessment methodology, based on the Data Envelopment Analysis (DEA) on the countries of the European Union, during the period 2005-2012. DEA is considered to be one of the most successful approaches in the field of economic assessment of the environment [Glover2009]. In fact, [Zhou2008] has compiled more than 100 articles, which apply DEA in terms of environment and energy. Within these studies, many works of this nature divide the output into two categories, desirable and undesirable. Our paper follows this line, according to the model proposed by [Sueyoshi2013, 2015]. But instead of taking companies as units of analysis, we use the countries of the EU-28, looking for the influence of the different inputs used, especially of the consumption of renewable energy, on the selected output, measured this influence in terms of Natural and Managerial efficiency in each one of these countries, with special attention to the case of Spain [Menegaki2013, Woo2015]. With this novel approach, we want to contribute to shed light on the effectiveness of the EU's energy policy in its commitment to the fight against climate change [European Commission, 2010]. Results of the DEA are complemented by the Malmquist index, used to obtain Natural and Managerial efficiency from a static and dynamic point of view, considering the possibility of a border crossing between one period and another due to technological progress.

2 Methodology and data

In this section, we begin by outlining two concepts associated with the environmental protection assessment that derive from the application of DEA methodology to the environment and which have been proposed by [Sueyoshi2012a, Sueyoshi2012b, 2012c, 2012c, 2012d, 2012e, Sueyoshi2013, Sueyoshi2014] to measure Natural efficiency and Managerial efficiency of different decision-making units (UDs). The first concept refers to the natural availability, "Natural disposability", which indicates that the UDs consider that in order to reduce undesirable output, the input vector must be reduced, and in parallel if it is possible to increase the desired output vector [Sueyoshi2012b, 2012c] or at least not decrease it. On the other hand, the managerial availability, denominated "Managerial disposability", indicates the opposite situation to the previous one. In this case, the UDs increase the input vector with the objective of decreasing the vector of undesirable outputs, for which it needs to employ innovative technology that produces this fact; and in parallel if it is possible to increase the desired output vector.

Chosen variables for this study are six: four inputs and two outputs, for the years 2005 to 2013. The inputs are total employment (in thousands of people), energy consumption (in thousands of Toe), energy consumption (in thousands of Toe) and the BCF deflated by the HIPC (Harmonized Index of Consumer Prices) for each country and year (in millions of euros) (Eurostat). As for outputs, two are considered, one desirable and one undesirable. The first is GDP in constant terms, for which the same price index has been used as to deflate the BCF (expressed in millions of euros). The undesirable output is GHG emissions (in thousands of tonnes of CO2 equivalent).

3 Results

This study analyzes the natural and managerial efficiency following the model of [Sueyoshi2013] and it also analyzes the evolution of the Malmquist index for the period 2005 to 2013 and for all the countries of the EU-28.

3.1 Natural and Managerial efficiency.

Natural and Managerial efficiency, associated with the existence of desirable and undesirable outputs, indicate the extent to which countries attempt to meet the so-called Natural disposability and Managerial disposability strategies. Both strategies seek to increase desirable output and reduce undesirable output. While "Natural disposability" is based on the reduction of inputs, "Managerial disposability" focuses on improving technology to achieve its targets, increasing inputs or maintaining them.

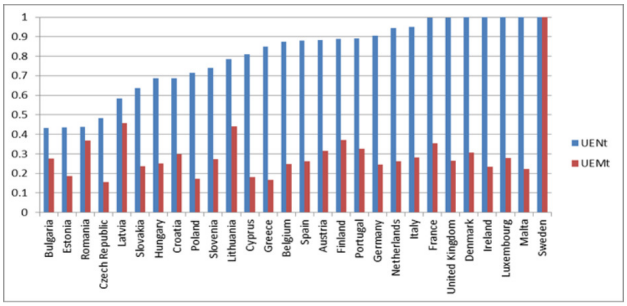

Figure 1: Average of Natural and Managerial efficiency for EU-28 countries. Period 2005-2013.

As shown in Figure 3, Sweden is the only country that is efficient in both directions. It should be noted that the Swedish economy has certain peculiarities. This explains the strong commitment of the Swedish State to a sustainable economy, in fact one of the countries that has managed to decouple the growth of the economy, GHG emissions and energy consumption. Specifically, Sweden is the sixth country in percentage growth of GDP in this period and

the fifth in emissions reduction. This commitment comes from years ago, since Sweden is one of the countries that has bet more on green tax incentives [Cansino2011], in addition to having established one of the instruments, which seems to have contributed to this, such as the carbon tax introduced in 1991 [Jagers2009, Hamar2011]. Sweden is also the second country (after Luxembourg) to have contributed the most per capita to the United Nations Green Climate Fund for the period 2015-2018. Focusing on the case of Spain, and comparing it with the EU-28 averages separated into two blocks, we can observe that in the case of natural efficiency (Fig. 2), the trend is similar to that of the countries in the block old, but starting from a lower position. The trend is bullish in general, but the impact of the economic crisis from 2009 to 2011 is clearly visible, with efficiency beginning to pick up again in 2012. In the case of Spain, it could be an effect of the reduction of public spending, GCF, Wages and employment. Specifically, public spending on the annual growth rate has been declining until 2011, a decline of -1.1 % from 2010 (Eurostat). The evolution of GCF since 2007 is decreasing, with 2009 being the year with a negative rate of change of 19 %. As regards the variable wages, its growth slowed in Spain in 2008, reaching -0.5 % in 2012, compared to 2011 (Eurostat). On the other hand, employment has been reduced throughout the period, the highest growth rates of unemployment occur in the years 2008 and 2009 (40 % and 60 %, compared to the previous year), which may partly explain the growth of efficiency in that period, a behavior that becomes in 2012, coinciding with an increase in unemployment, in this case of 16 %, compared to 2011 (INE).

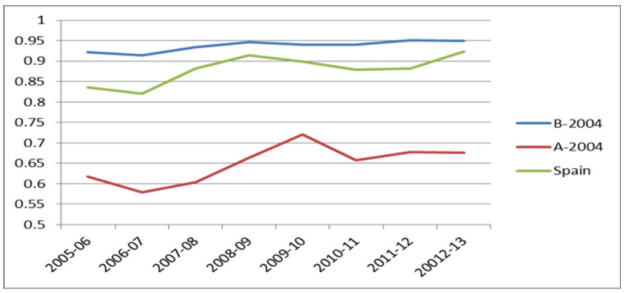

Figure 2: Comparison of the average Natural efficiency of Spain and the EU-28 countries (2005-2013).

In terms of management efficiency, the results are more disparate between the block, which we have included in Spain and its real position. One explanation may be due to the fall in Spain's share of renewable energies in 2010, with the annual growth rate of 2011 being negative. In all three cases, this decline is appreciated, but in the countries with a longest time in the EU-28, they start from a higher position and Spain follows the trend of the Eastern block.

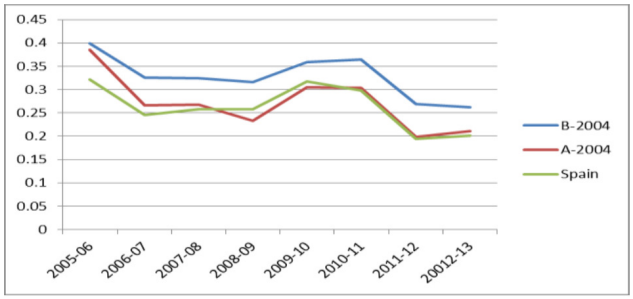

Figure 3: Comparison of the average Managerial efficiency of Spain and the EU-28 countries (2005-2013).

3.2 Malmquist Index

Malmquist index (MI) has been calculated for Natural and Managerial efficiency, assuming that there is border crossing between periods.

The evolution of this index in Spain, differs from

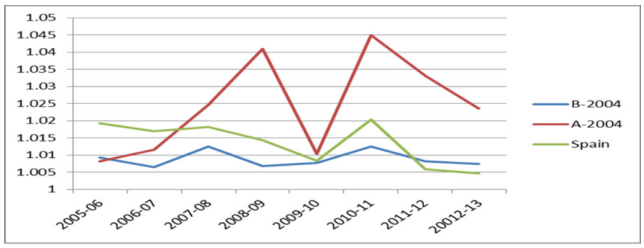

Figure 4: Evolution of the Malmquist Index based on natural efficiency. Period 2005-2013.

other countries in the block to which it belongs. Spain's behavior coincides with the trend described in [Woo2015], which attributes it directly to the global economic crisis. This may be due to the start of the slowdown in the Spanish economy in 2007, which is confirmed in 2008 (the GDP growth rate is -0.008 %, compared to 2007 (Eurostat, 2008)), for which the fiscal stimulus measures were not correctly articulated. The behavior in terms of blocks is contrary in the case of MI based on the management approach, as shown in Fig.7. Although there are still improvements in efficiency, the values in general are higher than for the natural approach. In this case, except for the central years of the economic crisis, (2007 to 2011), the evolution of the countries is very similar.

4 Conclusions

The period analyzed has been marked by the global economic crisis, as evidenced by the results and data

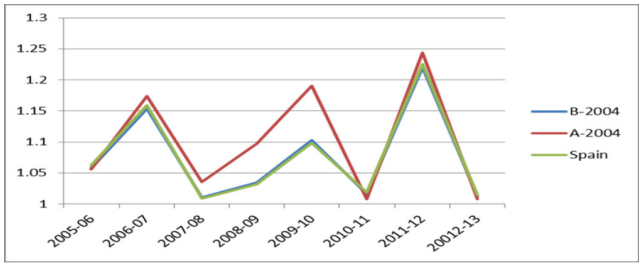

Figure 5: Evolution of the Malmquist Index based on management efficiency. Period 2005-2013.

reflected in this study. The crisis has affected some countries with greater virulence, as it is the case of Spain, which has reflected that this country, in some of the aspects analyzed is far from following the trend of the countries of the cluster to which it would belong. The western bloc of the EU stand out with the highest levels in the efficiency analysis. Spain is in the last position in this block for Natural efficiency and a similar trend in Managerial efficiency. These differences between Spain and the EU Bloc West have been highlighted especially in the analysis of the evolution of the Natural Malmquist Index. In the managerial case, the similarities are greater. Results obtained could justify, on the one hand, the contribution of the EU's regional policy to the convergence of its member states, by reducing some of its economic differences as in the case of natural efficiency and, on the other hand, over time, environmental policy is proving effective in pursuit of the technological progress necessary to improve levels of managerial efficiency. This implies that governments should continue in the line of implementing policies to promote the production of clean energy, as agreed at the Paris Climate Summit in December 2015.

Acknowledgements

This research is partially funded by the Spanish Ministerio de Economa y Competitividad , HERMES (TIN2013-46801-C4-1-r), Simon (P11-TIC-8052) and the Gobierno Regional de Andaluca (SEJ- 132), the Gobierno Regional de Andaluca through the Ctedra de Economa de la Energa y el Medioambiente de la Universidad de Sevilla, as well as the Ministerio de Economa y Competitividad del Gobierno de Espaa (ECO2014-56399-R).

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